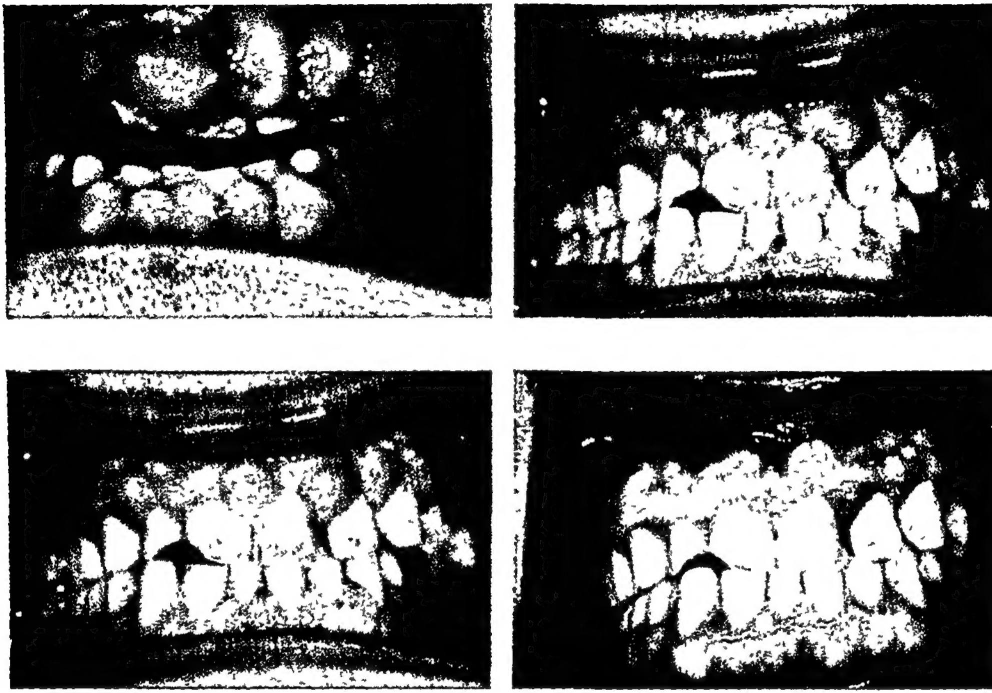
ORAL DIAGNOSIS AND TREATMENT

a b



c d

Dilantin Enlargement. Male, aged 16. Had been taking dilantin for two years.

(a) As presented after two previous attempts at elimination of hypertrophy by surgical gingivectomy.

(b) After toothbrush and rubber-cup massage for three months Dilantin was *not* discontinued.

(c) Same case six months later on only gingival massage.

(d) Same case one year later. Dilantin was still being taken.

ORAL DIAGNOSIS AND TREATMENT

(ORAL MEDICINE)

A Textbook for Students and Practitioners of Dentistry and Medicine

SAMUEL CHARLES MILLER, D.D.S., F.A.C.D., F.A.D.M.

Professor of Periodontia and Oral Medicine
Chairman, Department of Periodontia and Oral Medicine
New York University College of Dentistry

AND THIRTY-SEVEN CONTRIBUTORS

WITH AN INTRODUCTION BY

RAYMOND J. NAGLE, D.M.D., F.A.C.D.

Dean, New York University College of Dentistry

Third Edition

577 ILLUSTRATIONS IN BLACK AND WHITE AND 30 COLOR PLATES

THE BLAKISTON DIVISION
McGraw-Hill Book Company, Inc.
New York Toronto London 1957

ORAL DIAGNOSIS AND TREATMENT

Library of Congress Catalog Card Number 56-12271

THE MAPLE PRESS COMPANY, YORK, PA

This book is dedicated to Raymond James Nagle who, as Dean of the New York University College of Dentistry, has fostered in every way possible the development of the science of oral medicine

and

to the contributors and collaborators whose efforts have gone into its preparation

CONTRIBUTORS

MORRIS BALINE AUERBACH, D.D.S., F.A.C.D., Associate Professor and Chairman, Department of Endodontia, New York University College of Dentistry.

ARTHUR J. BARSKY, M.D., D.D.S., Visiting Surgeon, Chief of Plastic Surgery, Bronx Municipal Hospital Center; Clinical Professor, Plastic Surgery, Albert Einstein College of Medicine; Associate Surgeon in charge of Plastic Surgery, Mt. Sinai Hospital; Attending Plastic Surgeon, Beth Israel Hospital; Attending Plastic Surgeon, Bronx Hospital; Clinical Professor of Surgery and Associate Surgeon, New York Polyclinic Medical School and Hospital; Associate in Surgery, New York Medical College; Consulting Plastic Surgeon, New York State Rehabilitation Hospital; Consulting Plastic Surgeon, Beth El Hospital.

R. J. BEHAN, M.D., Dr.Med. (University of Berlin), F.A.C.S., F.I.C.S., Surgeon, St. Joseph's Hospital; formerly Surgeon, City Hospital at Mayview, and Leech Farm Tuberculosis Hospital; Ex-President, Allegheny County Medical Society.

J. LEWIS BLASS, D.D.S., Ph.G., F.A.C.D., F.A.D.M., Associate Professor of Periodontia and Oral Medicine, and Lecturer on Practice Management, New York University College of Dentistry; Consultant in Periodontia, Samaritan Hospital; formerly Chief of Periodontia, St. Luke's Hospital.

LOUIS BLATTERFEIN, D.D.S., F.A.C.D., Associate Professor of Denture Prosthesis, New York University College of Dentistry; Consultant, Veterans Administration Hospital, Lyons, N.J.

HAROLD KEITH BOX, D.D.S., Ph.D., F.R.M.S., Research Professor of Periodontia, University of Toronto.

FINN J. BRONNER, D.D.S., F.A.C.D., formerly Professor of Operative Dentistry and Comparative and Dental Anatomy, New York University College of Dentistry.

LOUIS R. BURMAN, D.D.S., Ph.G., F.A.C.D., F.A.D.M., Assistant Professor of Periodontia and Oral Medicine and Anatomy, New York University College of Dentistry; Periodontist, Morrisania City Hospital; formerly in charge of Research Division, Department of

Periodontia and Oral Medicine, New York University College of Dentistry.

Anthony C. Cipollaro, M.D., Professor and Director, Department of Dermatology, New York Polyclinic Medical School and Hospital; Associate Professor of Medicine (Dermatology), Cornell University Medical College.

David H. Coelho, D.D.S., Professor and Chairman, Department of Fixed Partial Prosthesis, New York University College of Dentistry

Charles G. Darlington, M D., F.C A.P., Professor of Pathology and Director, Undergraduate Cancer Teaching Program, New York University College of Dentistry; Colonel, Medical Corps, United States Army, Ret.

Jacob A. Englander, D.D.S., F.A.C.D., Assistant Professor of Endodontia, New York University College of Dentistry; Chief of Endodontics, Jersey City Medical Center.

LeRoy M. Ennis, D.D.S., F.D.S., R.C.S. (England), Professor and Chairman, Department of Roentgenology, School of Dentistry, and Professor of Oral Roentgenology, Graduate School of Medicine, University of Pennsylvania; Consultant in Dental Roentgenology to United Stated Navy, United States Army, and Veterans Administration; Advisor and Consultant on Dentistry, Egyptian Government.

Roger G Gerry, D.M.D., Captain, Dental Corps, United States Navy, Oral Surgeon, United States Naval Hospital, St. Albans, N.Y ; Research Assistant, School of Dental and Oral Surgery, Columbia University.

Samuel Hemley, D.D.S., F.A.C.D., Professor and Chairman, Department of Orthodontics, New York University College of Dentistry.

Milton Hollins, D.D.S., Assistant Professor, Department of Periodontia and Oral Medicine, New York University College of Dentistry.

Milton Hyman, D.D S., Professor of Oral Diagnosis and Chairman, Department of Oral Diagnosis and Roentgenology, and Secretary, Undergraduate Cancer Teaching Program, New York University College of Dentistry; Dental College Liaison Representative to Beth Israel Hospital.

Bernard J. Johnston, Jr., M.D., Neurological Examiner, Regional Office of Veterans Administration, Pittsburgh

Herbert H. Kabnick, D.D.S., Lecturer on Oral Reconstruction, Thomas W. Evans Museum and Dental Institute School of Dentistry, University of Pennsylvania; formerly Associate Professor in charge of Crown and Bridge Department, New York University College of Dentistry: Restorative Department, Montefiore Hospital.

Kermit F. Knudtzon, D.D.S., Associate Professor of Public Health and Dental Science, University of North Carolina School of Dentistry; National Consultant in Dentistry to the Surgeon General, United States Air Force.

Frances Krasnow, Ph.D., Research Consultant; Editor, International Association for Dental Research, New York Section; Member, Planning Committee, American Association for the Advancement of Science, Section on Chemistry.

I. Newton Kugelmass, M.D., Ph.D., Sc.D.Spèc., Consultant, Department of Health and Hospitals, New York City; Consultant Pediatrician, Heckscher Institute for Child Health, Manhattan General Hospital; Monmouth Memorial Hospital; Muhlenberg Hospital; Lynn Memorial Hospital; Northwoods Sanatorium, Saranac.

Joseph Simeon Landa, D.D.S., F.A.C.D., Professor of Prosthetic Dentistry, Postgraduate Division, and formerly Clinical Professor of Oral Diagnosis, New York University College of Dentistry; Attending Prosthodontist, Polyclinic Medical School and Hospital; Associate Attending in Dentistry, Beth Israel Hospital.

Moses Aaron Levy, D.D.S., formerly Instructor, Crown and Bridge Department, New York University College of Dentistry.

Don Chalmers Lyons, D.D.S., Ph.D , F.A.P.H.A., F.A.M.W.A., F.A.A.A.S., Consulting Staff Member, W. A. Foote Memorial Hospital; Consulting Staff Member, Mercy Hospital; Director, Lyons Research Laboratories.

John Oppie McCall, D.D.S., Consultant in Dentistry, New York Hospital and New York Eye and Ear Infirmary; formerly Professor of Periodontia, New York University College of Dentistry; formerly Director, The Murry and Leonie Guggenheim Dental Clinic.

Samuel Charles Miller, D.D.S , F.A.C D., F.A.D.M., Professor and Chairman, Department of Periodontia and Oral Medicine, New York University College of Dentistry; Honorary Professor, University of Santo Domingo, Attending in Oral Medicine, Polyclinic

Hospital and Medical School, Consultant in Oral Medicine, Jewish Chronic Disease Hospital; Consultant in Oral Medicine, Veterans Administration; Consultant and Postgraduate Teacher, United States Navy; Consultant in Oral Medicine, University Hospital.

RAYMOND J. NAGLE, D.M.D., F.A.C.D., Dean and Professor of Denture Prosthesis, New York University College of Dentistry; Past Chairman, Mass. State Board of Dental Examiners; formerly Central Office Consultant, Veterans Administration, Washington, D.C.; formerly Consultant in Prosthetics, Cushing General Hospital, Veterans Administration; Consultant in Prosthodontia, Manhattan Veterans Administration Hospital; Associate Editor, *Journal of Prosthetic Dentistry;* formerly Assistant Professor of Clinical Dentistry, and Director, Department of Complete Denture Prosthesis, Harvard School of Dental Medicine; Past President, Massachusetts Dental Society; Past President, American Academy of Dental Science; Past President, Academy of Denture Prosthesis, Chairman, Board of Consultants, The Murry and Leonie Guggenheim Dental Clinic

LEONARD M. NEVINS, D D.S., Captain, Dental Corps, United States Air Force; Chief, Oral Surgery Department, Sampson Air Force Base.

MARVIN N. OKUN, D.D S , Instructor, Department of Periodontia and Oral Medicine, New York University College of Dentistry; Assistant Editor, *Journal of Dental Medicine,* Periodontist, Queens General Hospital; formerly Instructor in Prosthetic Dentistry, New York University College of Dentistry.

MELVIN JON POMERANZ, D.D S., Instructor, Department of Periodontia and Oral Medicine, New York University College of Dentistry, Associate Attending and Chief of Periodontia, Midtown Hospital.

SIDNEY E. RIESNER, D.D S., F.A C.D., Special Lecturer in Postgraduate Courses, Columbia University, New York University, Tufts College Dental School, and University of Pennsylvania; Attending Dentist and Chief, Department of Orthodontia, Bronx Hospital; Orthodontist, Montefiore Hospital.

HAROLD H. SAGE, M.D., F.A.C.S., M.A.C.R., Assistant Professor of Surgery, New York University College of Medicine; Associate Professor of Oral Diagnosis, New York University College of Dentistry; in charge of Third Division Tumor Clinic, Bellevue Hospital.

J. A. Salzmann, D.D.S., F.A.P.H.A., Attending Orthodontist, Mount Sinai Hospital, New York.

S. Sigmund Stahl, D.D.S., Assistant Professor, Department of Periodontia and Oral Medicine, New York University College of Dentistry; Attending in Periodontia and Oral Pathology, Veterans Administration Hospital, Brooklyn.

Harold Stearns Vaughan, M.D., D.D.S., F.A.C.S., formerly Professor of Clinical Surgery, New York Post-Graduate Medical School of Columbia University; Attending Surgeon in Oral Surgery, New York Post-Graduate Hospital; Consulting Surgeon, Southampton Hospital; Consulting Oral Surgeon, Woman's Hospital, Hospital for Special Surgery, New Rochelle Hospital, Flushing Hospital, and North County Community Hospital.

George J. Whinston, D.D.S., Instructor, Department of Periodontia and Oral Medicine, New York University College of Dentistry; Assistant Editor, *Journal of Dental Medicine.*

George J. Witkin, D.D.S., F.A.C.D., Assistant Professor, Department of Periodontia and Oral Medicine, New York University College of Dentistry; Special Consultant, Municipal Civil Service of New York; Assistant Editor, *Journal of Dental Medicine.*

William Wolf, M.D., Ph.D., Attending Endocrinologist, Beth David Hospital; Consulting Endocrinologist, Misericordia Hospital; Consulting Physician, Department of Periodontia and Oral Medicine, New York University College of Dentistry.

Irving Yudkoff, D.D.S., Instructor, Department of Periodontia and Oral Medicine, New York University College of Dentistry; Editor, *Journal of Dental Medicine;* formerly Assistant Clinical Professor of Prosthetic Dentistry, New York University College of Dentistry.

PREFACE

In 1936, when the first edition of this text was published, ten years were still to elapse before the foundation of the American Academy of Dental Medicine. At that time, the awareness of the importance of proper diagnosis and case planning in dentistry was largely a matter of missionary effort. The second edition appeared the same year as the founding of the Academy in 1946 which was the crystallization of the needs of oral medicine in dental practice. Now, in only another ten years, the profession has reached the level of development wherein proper oral diagnosis and planning of treatment is considered standard responsibility; and the goal of a certification board in this special field has attained reality.

Thus, a millenium of progress has been compressed into a brief period of twenty years with an entirely new approach by the dental practitioner to his responsibilities to his patients, to his profession, and to his medical confreres. The present edition proposes to expand this heightening of awareness by the general practitioner as well as by the specialist.

The new and original diagnostic key devised by George Witkin is both instructive and practical. It can be used by anyone to reach a diagnostic decision; further details and the treatment to be planned are then found by consulting the indicated portions of the text. The entire text has been completely modernized and rewritten. Questions have been placed at the end of each chapter to make the book even more valuable for undergraduate and postgraduate teaching The third edition is also enhanced by entirely new chapters on Diagnosis of Pulp Abnormalities and Their Treatment, by Morris B. Auerbach and Jacob A. Englander; Partial-denture Design and Planning, by Louis Blatterfein; The Surgical Management of Oral Disease, by Roger Gerry; Pain of Dental Origin, by Milton Hyman; Aviation Dentistry (Aerodontia), by Kermit F. Knudtzon; Hyperplasia, Benign Tumors, and Cancer of the Oral Cavity, by Harold H. Sage; and a thorough consideration of the Etiology of Periodontal Disease.

The editor is indebted to Melvin J. Pomerantz and George J. Whinston for preparing the questions; to Abraham Goldstein and Nathan Wachtel for developing the index; to Allan N. Arvins, Harry Blechman, Sidney Sorrin, and Arthur N. Yohai for checking proofs; and especially to Marvin N. Okun and Irving Yudkoff for their efforts in attending to many of the responsibilities incident to such a large editorial undertaking.

Rea Fein, Lenora Murphy, Ida V. Kegeles, Ruth Rosen, Annette Sem, and Zelda Edery aided greatly in the editing and typing of the manuscript. Helen Kovacs, Assistant Curator and Librarian, and Miniva I. Williams, Assistant Librarian, New York University College of Dentistry, spent time checking all bibliographic references

Samuel Charles Miller

CONTENTS

INTRODUCTION

Having spent my entire professional life in various phases of dental teaching, I have been able to watch the development of dental education for the past thirty years. The progression from a simple mechanical endeavor to a complete oral health service in this comparatively short span has been nothing short of remarkable. Having also carried on a private practice through practically all this time, I have been impressed with the clinical application of everything that is taught. The best student, whether an undergraduate or a practicing dentist, turns out to be the happiest and most productive in rendering effective care to his patients.

Dental techniques have reached an acme of perfection in the last few years which permits success in most phases of dental practice. However, the choice of procedures and the method of application need much emphasis in teaching and practice. The student and the practitioner must be equally aware of the iatrogenic hazards of misapplied or poorly chosen treatment. The great abundance of knowledge required by the dental practitioner in all phases of general health preservation and in the prevention and control of diseases requires many areas of study on the part of the general practitioner as well as the specialist. These are best correlated in a book of this type.

The physician also should be able to participate in correlated diagnoses and to advise his patients intelligently when called upon to give his views on dental health measures and discuss them intelligently with the dentist.

When the first edition of this book was in preparation, L. Pierce Anthony, in an editorial in the *Dental Cosmos*, admonished:

> In days gone by, a faulty or mistaken diagnosis was more or less excusable, and today such is the case in many obscure conditions, but with the evolution and development of numerous adjuncts to dental and medical practice, together with a broader knowledge of human ills, there is little excuse for failure to properly diagnose the ordinary conditions which are continuously coming under the purview of the dentist.

How much truer this is a little more than twenty year's later!

Dental and medical practitioners can use a book such as this one as a daily guide as well as a rich source of the most modern information presented concisely and clearly by authorities in all phases of this broad subject. The diagnostic key is a fascinating example of the many additions which place the third edition of this already standard text far ahead in the march of scientific progress toward the true goal of oral medicine.

Raymond J. Nagle

CHAPTER XXX

Tumors of the Foot and Ankle

CHAPTER XXXI

CHAPTER XXXII

Abnormalities and Affections of the Toenails

CHAPTER XXXIII

Foot Hygiene and Sanitation—"Minor" Care of the Feet

CHAPTER XXXIV

The Relation of Back, Pelvis, Hip, Thigh, Knee and Calf to the Foot and Ankle

CHAPTER XXXV

Surgical Technic as Applied to the Foot and Ankle

Appendix

FOOT AND ANKLE

INTRODUCTION

The foot is an important link between a person and the earth It is developed in a manner similar to that of the hand * The posterior limb bud appears during the third week of gestation

The physiology of the foot and ankle involves a member which must afford stability, movement, comfort, strength, good circulation, and an adequate nerve supply A small degree of painless, free ankle motion is essential to a graceful step The test of normality in the arch lies not in its height, but in the correct alignment of its component bones and the action of its muscles and ligaments A foot with a low arch but with normal weight distribution may be a better foot than one with a high arch but with improper distribution of weight

Foot conditions comprise the following groups congenital defects, deformities and disabilities, acquired deformities and disabilities, diseases of bones, joints, muscles, and nerves, traumatic conditions of bones, joints, muscles, and nerves, paralytic conditions, circulatory disturbances, and tumors

Congenital defects consist of absence of toes, the presence of constricting bands and supernumerary toes, syndactylism, hypertrophy, overgrowth of the leg and foot, overlapping toes, and bipartite sesamoid bones

Congenital deformities include various types of talipes

Acquired deformities may be due to tuberculosis, syphilis, poliomyelitis, spastic paralysis, infections, flat-foot, metatarsal depression, bursitis, hallux valgus, or exostoses

Traumatic conditions include fracture, dislocation, epiphyseal separation, and epiphysitis Warts, papillomas, corns and most circulatory disturbances are acquired

The chief diseases of the foot are tuberculosis, osteomyelitis, epiphysitis, and osteochondritis, such as Kohler's tarsal scaphoiditis Freiberg's infraction of the metatarsal head, apophysitis of the os calcis, arthritis due to the gonococcus, staphylococcus, or streptococcus, and metabolic and traumatic causes are common in the foot

* An interesting article on the history of the evolution of the human foot by Sir Arthur Keith appeared in the Journal of Bone and Joint Surgery January 1929

The chief tumors of the foot are lipomas, fibromas, osteomas, angiomas, hemangiomas, cysts and sarcomas.

I consider the most common foot complaint to be tired, aching, weak feet. The most common conditions for which the orthopædic surgeon is consulted are metatarsalgia and hallux valgus in women; flat-feet in children, and flat-feet and painful heels in men. The majority of people go to the chiropodist for the treatment of corns, calluses and ingrown toenails. They consult a dermatologist for ringworm and other skin affections.

People with foot troubles should consult their family physician who should be qualified and equipped to treat the common disabilities and complaints of the foot. If he is not, he will send them to an orthopædic surgeon.

Morton's tests made with the staticometer demonstrate that each metatarsal bone transmits an approximately equal amount of weight, with the exception of metatarsal I, which carries a double load. He located the axis of balance between metatarsals II and III.

The sustentaculum tali is an important part of the subtalar joint around which the position and movements of the foot and ankle produce "foot balance."

A moderate degree of intermittent pigeon toes is not serious.

Every adult's foot should have, especially in summer, a daily bath, following which it should be thoroughly dried and powdered. If there is any tendency toward ringworm or excoriation, a dermatologist should be consulted. Every child's foot should have a daily bath and powder.

One cannot always judge from the shape of a foot what its symptoms and performance will be. People with high longitudinal and low transverse arches and calluses may feel better in high-heeled shoes. Thick, fat-ladies' ankles with obliteration of Achilles tendon due to water-logging may indicate cardiorenal disease. The Achilles area is often an indicator of disturbances of the general health. It is impossible to estimate with any reasonable degree of accuracy the percentage of men, women and children who have foot troubles. Figures often printed have never been substantiated.

Recent advances in the treatment of foot and ankle conditions have been made in poliomyelitis, club-foot, arthritis, epiphysitis, and fractures. Noteworthy progress has been made in regard to the treatment of infections.

The person who said "Position is everything in life" spoke like an orthopædic surgeon. Position may be paramount in determining the usefulness of a limb. Function may be disturbed by discomfort, deformity, or disability.

The foot, especially in the young, is very plastic; continued pressure can give it almost any shape. A familiar example is the foot of the high-

caste Chinese lady By a system of bandaging, begun at the fifth or sixth years, the anterior half of the foot, by extreme flexion at the midtarsus, is made to approach the posterior, so that the toes and heel may fit into a dainty little shoe no larger than a teacup

The foot and ankle is a complicated piece of biological machinery

Muscles are not capable of supporting body weight indefinitely

If your hand hurts you can put it in your pocket or in a sling and go on your way, but not so with your foot

FUNCTION OF THE FOOT AND ANKLE

The surgeon thinks in terms of

1 Life
2 Function

Function means { Performance, Usefulness, Comfort }

The Functions of the Hand are to	
Grasp	Touch
Pinch	Press
Hook	Compress

The Functions of the Foot and Ankle are to	
Bear weight	Kick
Grasp the ground	Propel
Walk	Push objects
Run	Touch
Spring from the ground	Feel

Position of Function of Foot and Ankle—Just as in the hand we have Kanavel's Position of Function, similarly, in the foot we have

1 Neutral or a few degrees of supination and varus
2 About 5 to 10 degrees of equinus

Perfect Foot Function Includes the Performance
1 Of normal movements
2 Repeatedly
3 Consistently
4 With comfort
5 With useful purpose
6 With gracefulness
7 With poise
8 With balance
9 With power
10 Without undue fatigue

You cannot tell the functional capacity of a foot while the person sits.

Do Not Add Insult to Injury
1. Injury 2. Infection 3. Exposure 4. Insult*
* Improper treatment.

The 5 D's of Orthopædic Surgery
1. Defect 2. Discomfort 3. Deformity 4. Disability 5. Dislike*
* Psychosomatic factors.

Trouble Spots of the Foot and Ankle.—The trouble spots of the foot and ankle as evidenced by the reflection of a busy private practice, hospital practice and out-patient practice, reveals that the largest number of people who consult a doctor, do so because of painful feet in general or tired feet where the fatigue comes on toward 3 or 4 o'clock in the afternoon. Tired and painful feet occur in persons who are compelled to be on them a great deal a large share of the day, such as waitresses, policemen, traveling salesmen, shop girls, beauty specialists, hair dressers, and other workers.

These people as a rule feel fine when they waken; they feel well until 3 or 4 P.M. when the feet get tired. Then they begin to get painful and the person walks as though he is walking on egg shells. So far as the overall picture is concerned, it is the pain of fatigue.

In regard to the anatomical locations of the most commonly affected parts that bring persons to a physician, one recognizes the following:

1. Astragalo-scaphoid area.
2. Subastragalar joint on the inner border of the foot.
3. Pain in the region of the metatarsal arch and especially the region of the 4th metatarsal head.
4. Pain in the area of the big toe joint.
5. Pain in the little toe.
6. Pain in the heel, most commonly on the under surface, in the spur bearing area, and the region of the heel where the counter of the shoe presses on the periphery of the heel.
7. Overbone, where the first metatarsal base and first cuneiform meet.

8 Hammer toes where there is a corn or a callus at the apex of the toe, due to pressure of the shoe

9 Fungus or ringworm infection

The Most Common Causes of Foot Complaints During Military Training
1 Incorrect fitting of shoes
2 Improper shoes—poor condition
3 Incorrect fitting of socks
4 Improper socks—poor condition
5 Inadequate graduated physical and mental conditioning of unseasoned troops
6 Improper arch protectors or supports
7 Foot disturbances*
8 Skin lesions†
* Of bones, joints, muscles, tendons, ligaments, blood-vessels, bursæ, arches, foot strain, metatarsalgia, heel bruise
† Blisters, abrasions, infections, disturbed sensations

DISABILITIES OF THE FOOT

According to Bick, the importance of foot disabilities other than those causing obvious gross deformity, was not appreciated by the medical profession until the 18th century, when Peter Camper of Amsterdam wrote his *Dissertation on the Best Form of Shoes* (1781) The first serious scientific study of human gait appeared in a volume on the mechanics of locomotion, published by the Weber brothers in 1836 Carlot made graphic records of the human gait by means of shoes built with rubber soles which contained air compression chambers of the heel and forefoot Bradford was among the first of the American orthopædic surgeons to study the problem Muybridge used an electric photographic method for recording gait The most recent advance in the study of gait has been made by R Plato Schwartz and his co-workers, whose electrobasographic method of recording gait, has offered refinements in this study

Toward the end of the 19th century, Whitman distinguished between true flat-foot, an often hereditary, usually non-symptomatic anomaly, and pseudo-flat-foot, in which the foot and leg become everted, painful, and in advanced cases, more or less rigid

Keith, emphasized the fact that the interosseous ligaments are but secondary supports in weight-bearing extremities, and are called into play only when the musculature of the part becomes ineffective He referred to them as the "fatigue structures" and maintained that their stretching or elongation by persistent passive strain indicated inadequacy of the muscles concerned The osseous theory of this

You cannot tell the functional capacity of a foot while the person sits.

Do Not Add Insult to Injury
1. Injury 2. Infection 3. Exposure 4. Insult* * Improper treatment.

The 5 D's of Orthopædic Surgery
1. Defect 2. Discomfort 3. Deformity 4. Disability 5. Dislike* * Psychosomatic factors

Trouble Spots of the Foot and Ankle.—The trouble spots of the foot and ankle as evidenced by the reflection of a busy private practice, hospital practice and out-patient practice, reveals that the largest number of people who consult a doctor, do so because of painful feet in general or tired feet where the fatigue comes on toward 3 or 4 o'clock in the afternoon. Tired and painful feet occur in persons who are compelled to be on them a great deal a large share of the day, such as waitresses, policemen, traveling salesmen, shop girls, beauty specialists, hair dressers, and other workers.

These people as a rule feel fine when they waken; they feel well until 3 or 4 P.M. when the feet get tired. Then they begin to get painful and the person walks as though he is walking on egg shells. So far as the overall picture is concerned, it is the pain of fatigue.

In regard to the anatomical locations of the most commonly affected parts that bring persons to a physician, one recognizes the following:

1. Astragalo-scaphoid area.
2. Subastragalar joint on the inner border of the foot.
3. Pain in the region of the metatarsal arch and especially the region of the 4th metatarsal head.
4. Pain in the area of the big toe joint.
5. Pain in the little toe.
6. Pain in the heel, most commonly on the under surface, in the spur bearing area, and the region of the heel where the counter of the shoe presses on the periphery of the heel.
7. Over bone, where the first metatarsal base and first cuneiform meet.

8 Hammer toes where there is a corn or a callus at the apex of the toe, due to pressure of the shoe

9 Fungus or ringworm infection

The Most Common Causes of Foot Complaints During Military Training
1 Incorrect fitting of shoes
2 Improper shoes—poor condition
3 Incorrect fitting of socks
4 Improper socks—poor condition
5 Inadequate graduated physical and mental conditioning of unseasoned troops
6 Improper arch protectors or supports
7 Foot disturbances*
8 Skin lesions†
* Of bones, joints, muscles, tendons, ligaments, blood-vessels, bursæ, arches, foot strain, metatarsalgia, heel bruise
† Blisters, abrasions, infections, disturbed sensations

DISABILITIES OF THE FOOT

According to Bick, the importance of foot disabilities other than those causing obvious gross deformity, was not appreciated by the medical profession until the 18th century, when Peter Camper of Amsterdam wrote his Dissertation on the Best Form of Shoes (1781) The first serious scientific study of human gait appeared in a volume on the mechanics of locomotion, published by the Weber brothers in 1836 Carlot made graphic records of the human gait by means of shoes built with rubber soles which contained air compression chambers of the heel and forefoot Bradford was among the first of the American orthopædic surgeons to study the problem Muybridge used an electric photographic method for recording gait The most recent advance in the study of gait has been made by R Plato Schwartz and his coworkers, whose electrobasographic method of recording gait, has offered refinements in this study

Toward the end of the 19th century, Whitman distinguished between true flat-foot, an often hereditary, usually non-symptomatic anomaly, and pseudo-flat-foot, in which the foot and leg become everted, painful, and in advanced cases, more or less rigid

Keith, emphasized the fact that the interosseous ligaments are but secondary supports in weight-bearing extremities, and are called into play only when the musculature of the part becomes ineffective He referred to them as the "fatigue structures" and maintained that their stretching or elongation by persistent passive strain indicated inadequacy of the muscles concerned The osseous theory of this

deformity, which gave to it the popular name of "fallen arches," was based on the assumption, that the bony longitudinal arch of the foot is a true arch with the navicular or head of the astragalus as its keystone. In 1885, Shaffer described a painful static foot deformity characterized by a high longitudinal arch and extended proximal phalanges, a mild pes cavus or hollow foot, which he thought was due to a contracted tendo achillis. In 1876, T. G. Morton applied the term "metatarsalgia" to a type of foot disability in which severe pain occurred in the region of the metatarsal arch. He believed the symptoms to be neuralgic in character and described pain radiating into one or more toes as due to pressure on the digital nerves as they passed between the heads of the metatarsal bones. Goldthwait, in 1894, and Robert Jones, in 1897, demonstrated that the pain was caused primarily by a prolapse of the metatarsal arch. Another lesion producing similar symptoms had previously been described by Breithaupt (1885). This lesion, known variously as "march-foot," was fairly common among soldiers following long marches, and was treated as a strain or sprain until roentgenography disclosed the fracture of a metatarsal bone, which was not perceptible until some time after the appearance of the symptoms.

To Hugh Owen Thomas, all static deformities of the foot were problems of joints and ligaments rather than of muscles. For the treatment of flat-foot, he prescribed a lift with forward extension of the inner portion of the heel, an alteration still known as the Thomas heel. During the middle of the century the use of "arches" or foot plates came into vogue. Among orthopædic surgeons there has been a controversy between those advocating rigid and those favoring non-rigid support.

In the treatment of children, adolescents, and young adults, the tendency has been away from rigid supports and in favor of exercises aimed at strengthening the involved muscles. Although foot plates are frequently used for temporary assistance in the cases of young patients, many orthopædic surgeons are of the opinion that raising of the inner border of the heel is sufficient to invert the calcaneus. Exercises are planned to strengthen specifically the anterior and posterior tibial muscles, and in some instances the intrinsic muscles of the foot. Cases of painful feet represent a large proportion of private orthopædic office practice. Invariably, these cases have been seen by many shoe-salesmen and unqualified practitioners.

The rigid or spastic flat-foot presents a difficult problem. Most cases, however, can be improved by manipulation under anesthesia, followed by a plaster-of-Paris boot to maintain the over-corrected (inverted) position. After removal of the plaster, the foot is stretched daily for a prolonged period of time, and foot supports are worn.

For the very resistant cases, surgical intervention becomes necessary

There is no doubt that foot disturbances are reflected in the patient's general health and his attitude toward life When any of the 26 bones in the foot gets out of line or is put to undue stress or strain, trouble results In spite of the fact that the "heels together and toes apart position" has been the standard in armies all over the world for many years, it is a very poor position for walking on hard floors, cement sidewalks, and asphalt streets In the cases of overweight people, correct walking is of special importance to minimize the extra strain thrown upon the feet and legs

"Foot rhythm" produces a spring to the step which minimizes jars to the legs, back, and central nervous system It requires that the person contact the ground with the heel of his shoe, that his foot be turned slightly in varus position, and from that position toward the base of the little toe, and from there toward the base of the big toe over which the step is completed, so that the three points of pressure are the back of the heel, the outer border of the little toe, and the inner border of the big toe

One of the best measures to improve foot hygiene and comfort is changing of the shoes during the day This is especially indicated for business men Strain on the circulatory and neurocirculatory apparatus may be relieved by raising the feet and legs one at a time or both at one time on some article of furniture, even though this be done for just a few minutes The circulation in the foot is very important, and anything that can be done by heat, massage, contrast sprays, or elevations to improve it, is certain to have a good effect

The importance of the flat-foot problem is evidenced by the fact that it occupied about one-fifth of the entire 1946 meeting of the American Orthopedic Association

The Disproportionately Small Foot —There are a great many people who have small feet with a disproportionately large body, a combination causing serious disproportion between the size and power of the feet and the load they are compelled to carry Most of these people are better off in high-laced shoes during the period of reduction of weight

The High Arched Foot —The high arched foot is not necessarily a good serviceable foot It can be compared to a high bridge which is sagging in the middle and therefore continuously under strain

Standing Versus Walking —Most people with weak feet and many with normal feet find that standing is much more severe on them than walking The reason for this is that, in walking, the feet are momentarily relieved of weight-bearing after each step, whereas, in standing, they bear weight continuously The moments of rest in walking are

somewhat analogous to the pauses between heart beats, which give the heart rest.

Many patients have said to me "I can walk home 5 miles but if I have to stand on the street car I am exhausted by the time I get off." Morton very clearly emphasized the fact that foot action consists of an interplay between the static forces of gravity and dynamic force supplied by the muscles.

Familiarity with the static phase contributes a logical basis for appropriate planning of reconstructive work, and for predetermining the values of conservative or radical procedure.

Biomechanical analysis proves the importance of the forepart of the foot.

Patterns of Foot Disorders.—There are definite patterns of foot complaints which are primary and secondary.

It is important to determine whether the disturbance is in the ankle, subastragalar or astragalo-scaphoid joint. Then one must determine whether the trouble is in the midtarsal or metatarsal areas.

When the situation does not conform to an orthopædic pattern, one should call for help. The assistance most often needed is neurological.

The Subastragalar Joint.—The normal function of the foot revolves around the astragalus. The function and comfort of the foot are determined by the integrity of the subastragalar joint. If the ankle joint is disabled it throws strain on the subastragalar joint, and *vice versa*.

Key Features.—In the Diagnosis and Treatment of Foot Disability:

I. Astragalus—How does it receive its thrust?

Is the Helbing sign plus or minus?

The relation of the head of the astragalus to the os calcis and the scaphoid, while bearing weight, must be:

1. Free
2. Comfortable
3. Stable
4. Of normal excursion

II. Is active supination plus or minus?

III. Can the foot be fitted with a commercial or standard shoe?

Free foot function is imperative to walking comfort.

Comfortable ankle action is a prerequisite to walking function.

Remarks.—I rarely order custom made shoes, unless the patient has a deformed foot.

Splayed Foot.—In the splayed foot, the heels are close together, toes are far apart and there is outward rotation of legs. In this posture it is impossible to supinate feet and to properly flex the knees which is so important in a graceful, comfortable gait.

The Equinus Foot —The term is derived from the horse's hoof The chief causes are congenital, spastic and poliomyelitis. The deformity produces disability and discomfort If the condition cannot be prevented, its cure or correction is usually accomplished by manipulation, surgery and immobilization

Feet of Primitive People —There is a misconception that all primitive people and aborigines have excellent feet I have photographs and have seen many examples of marked valgus and pronation deformities in the feet of aborigines and primitive people Such people are not apt *to have corns, calluses, or bunions, but from the static point of view* they have longitudinal and transverse arch defects

Pregnancy —The foot of the pregnant woman is a very important member before, during and after delivery It is important that the pregnant woman do a certain amount of walking every day For this, her feet must be comfortable, strong, and properly shod Especially in the latter half of pregnancy, she is compelled *to* get practically all of her outdoor exercises in the form of walking She may do some exercises in the home, but she is unable to take part in athletics It is therefore imperative that she be kept in good condition by massage, contrast sprays, and the wearing of proper shoes Many women's feet have been ruined during pregnancy by improper shoeing

Infection —Many feet are ruined or jeopardized during or after illnesses by the wearing of bedroom slippers which supply no support for the arches Proper shoes are imperative during illnesses, especially those accompanied by fever

Poliomyelitis —There are about 200,000 poliomyelitis cripples in the United States. This is an enormous number which is especially striking when one considers that most of the crippling occurred between 1906 and 1939 Most victims of poliomyelitis have crippled feet The disease is on the increase and is attacking older age groups

The Operative Fusion of Bone Surfaces —Factors involved

1 Denudation
2 Approximation
3 Alignment
4 Immobilization

No interposing material may be permitted

The value of compression in the fusion of raw bones is generally recognized It is a matter of contraction *vs* distraction

Osteoblasts are not broadjumpers, but are good tight-rope walkers

At Mayo General Hospital we often had a census of 1,500 patients

with orthopædic conditions, including fractures, dislocations, crushing injuries, peripheral nerve lesions and peripheral vascular injuries. Some of these soldiers were admitted within thirty-nine hours of their overseas wounding; others had been wounded from seven to fourteen days previously.

Most common causes of certificate of disability (CDD) due to foot disorders are:

I. Rigid flat-foot.
II. Pes cavus.
III. Ankle disorders. (Incongruity of articulating surfaces.)

Inadequate Roentgen-ray Study.—One of the worst errors a physician can make is to fail to order roentgenograms because: 1. He does not evaluate signs and symptoms, or 2. He tries to spare the patient the expense.

The Myth of the Corrective Cast.—Is there such a thing as a corrective cast? Although the term is used loosely, it is generally understood what is meant. Most casts are used to *maintain* a position of correction or over correction that has been *obtained* by manipulation or by surgery.

Advice to Athletic Trainers.—There are many points regarding the shape of the feet in their relation to standing, sitting, walking, the wearing of shoes, and foot postures, which, if applied by persons in athletic occupations or activities, would have a very important, beneficial effect upon children and adults by increasing the efficiency and comfort of the feet. The people I refer to are gymnasium teachers, ballet dancers, directors of public activities such as those in parks, gymnasiums, swimming pools, military drill, shops, factories, and all kinds of athletics.

Chiropody.—A good chiropodist is a valuable member of society from the standpoints of foot hygiene and comfort. Unfortunately, many of those who need him most do not consult him. The poorly trained or unskillful chiropodist, the one who does not recognize the limitations of his specialty, and the unscrupulous chiropodist who, recognizing those limitations, attempts to care for conditions he is unqualified to treat, are undesirable persons.

The chiropodist must know the principles and practice of asepsis and antisepsis. In addition he should know the rules of shoe and stocking fitting, and should be able to recognize the common forms of nail and skin lesions.

Physicians should warn their patients to be careful to select a chiropodist who is well qualified and has good judgment. This is particularly important in the cases of diabetics, arteriosclerotics, patients with peripheral vascular lesions, and those with neurological lesions.

The common hyperkeratotic lesions of the feet include callus, hard,

soft and neurovascular corns, warts and plantar radiodermatitis Differentiation of these simple lesions and their proper treatment would prevent many unfortunate sequelæ

Shoe Salesman —Shoe salesmen should be impressed with the fact that the proper fitting of shoes is an important responsibility This is true especially in the cases of children and women I therefore offer them the following advice

1 Don't sell a shoe that may cause foot trouble
2 Don t try to treat a foot to sell a shoe
3 Don't try to make a shoe do what no one but an orthopædic surgeon can do
4 Don't attempt to render medical opinions
5 Never divert a customer from necessary medical consultation

CHAPTER I

EMBRYOLOGY AND ANATOMY OF THE FOOT AND ANKLE

DEVELOPMENT OF THE FOOT AND ANKLE

THERE was a phase in man's history when he used his foot as a grasping, climbing organ, much in the manner still retained by the monkey and chimpanzee.

Of the three great living anthropoids, the orang of Borneo and Sumatra and the chimpanzee and gorilla of equatorial Africa, the chimpanzee has retained the type of foot which is most likely to serve as the pattern from which the divergent types seen in the orang and in man have been derived. In the lower limbs of the orang and of man, evolutionary processes have worked in opposite directions. The great toe of the orang has undergone retrogression; that of man has undergone progression; the ordinary toes of the orang have become long, hooklike, grasping fingers; those of man have become reduced to mere accessories of the sole. The lower limbs of the orang have come to be used more and more as arms, and the feet as grasping organs, while in man the lower limbs have increased in static power, and his feet have become modified organs of support. Between these two instances of extreme specialization, the chimpanzee has kept along the middle course. The gorilla, however, which is certainly closely related to the chimpanzee, has made certain departures which help us to understand some of the changes which the human foot must have passed through in its progress from an anthropoid to a human status. Thus, the origin of man's foot is not an isolated problem; whatever may be the explanation we offer for the origin of man's foot, it must be one which is applicable to the feet of his structural allies—the gorilla, chimpanzee, and orang.

Muscles and Ligaments.—Attention must first be directed to the prime movers of the foot, its muscles. We must reckon the two peroneal muscles and the two tibial muscles among the purely postural muscles, whose main activities are directed toward the safeguarding of the arch. Ligaments are not directly concerned with the maintenance of the normal arch. Nature never uses ligaments as prime supporters in the structure of the animal body; muscles are always used for this purpose. Ligaments serve only as safeguards; they come into action only when the muscular defense has broken down. The ligament under the head of the astragalus, *i. e.*, inferior calcaneo-

scaphoid, carries superincumbent weight only when the reflex defensive mechanism of the tibialis posticus muscle has broken down.

In his lecture, given in memory of Hugh Owen Thomas, Sir Arthur Keith emphasized the following points:

1 The human foot has been evolved from one which was prehensile, the condition found in the foot of the chimpanzee is regarded as the nearest representative of the primitive form from which the feet of man, gorilla and orang have been evolved.

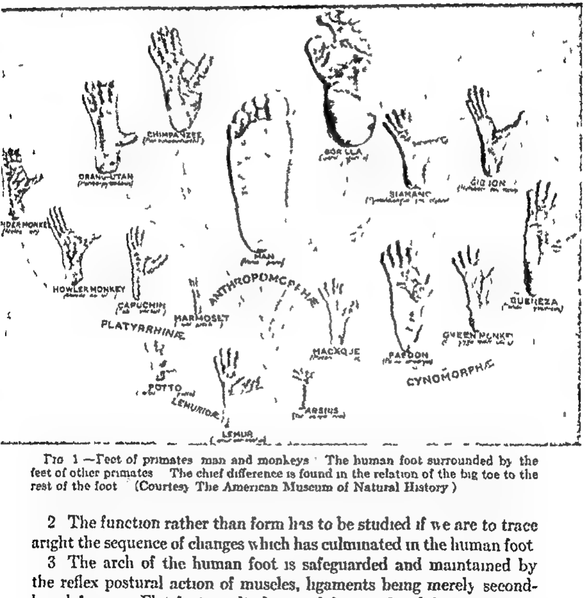


FIG 1 —Feet of primates man and monkeys The human foot surrounded by the feet of other primates The chief difference is found in the relation of the big toe to the rest of the foot (Courtesy The American Museum of Natural History)

2 The function rather than form has to be studied if we are to trace aright the sequence of changes which has culminated in the human foot.

3 The arch of the human foot is safeguarded and maintained by the reflex postural action of muscles, ligaments being merely second-line defenses. Flat-foot results from a defect in this defense.

4 The evolution of the various muscles concerned in maintaining the posture of the human foot—the tibialis anticus and tibialis posticus, peroneus longus and peroneus brevis and peroneus tertius—is traced from their state in the prehensile foot of apes to their action in the static foot of man.

5. The grasping muscles, the flexor longus digitorum, the flexor longus hallucis, flexor brevis digitorum and accessorius, become subservient to the static needs of the human foot.

6. The loss of prehensile action of the great toe and its incorporation in the plantar arch was brought about, by a shift not of the outer toes to the great toe, but from the great to the outer toes.

7. The short muscles of the great toe have assumed a new and important function in the human foot: that of maintaining the static use of the phalangeal part of the great toe.

8. The chief changes that have transformed a prehensile into a plantigrade foot are those of growth: *viz.*, a retrocession of growth affecting the external or plantar limb of the prehensile foot with a progressive growth in its hallucial limb.

9. In the evolution of the feet of higher primates four stages have to be recognized: (*a*) the pronograde prehensile foot; (*b*) the hylobatian or small orthograde foot; (*c*) the troglodytian or massive orthograde foot; and (*d*) the plantigrade or human foot. The foot of man has passed through the first of these three stages in its evolution.

10. Researches on the changes in the gorilla's feet and their bearing on the evolution of man's foot have been carried out recently by Drs. Dudley Morton and A. Schultz.

EMBRYOLOGY OF THE FOOT AND ANKLE

Of prime interest in a salient discourse on the embryology of the foot and ankle, is a description of the development of the osseous portion of this region and the anomalies which result from defects in this development.

As mesenchymal tissue differentiates into the various types of connective tissue, fibroblasts, osteoblasts, and osteoclasts develop, thus starting the production of a bony structure. It is believed that fibroblasts and osteoblasts have a common origin from the early fibroblasts. Osteoblasts build bone. Osteoclasts absorb excess bone elements and produce hardening of bone. These two types of cells carry on their activities synchronously. The architectural unit of bone is the lamella, which Fraser describes as a sheet of connective tissue impregnated with calcium salts. Bone grows through the gradual accretion of lamellæ. The original matrix of a long bone is condensed mesenchymal tissue composed in part of cartilage. Into this rather avascular framework blood-vessels penetrate, causing a disintegration of the cytoplasm of the cartilaginous cells, liberating the nuclei which then begin to assimilate calcium, and deposit it in the surrounding tissue. The extension of this process proceeding from the center of the shaft centrifugally, and independently at each epiphysis, finally results in ossification.

The embryology of a typical joint can be divided into three stages. In the first stage there appears an undifferentiated mass of mesenchymal cells, which becomes condensed in the region of the future joint. The second stage, which starts at about the eighth week of fetal development, consists of a process of liquefaction or separation, by which a transverse cleft is produced. This is to become the future joint cavity. In the third stage there occurs a process of selective differentiation by which some of the cells adjoining the cleft are transformed into articular cartilage cells, capsule cells, and synovial cells. (Fig. 2.)

The small buds of mesenchyme which are to become the lower limbs appear at about the third week of fetal life. The foot plate appears at the fourth week as a flattening of the end of this bud. The dorsum of the foot soon elevates, and a suggestion of the great toe appears.

With this brief general description of the embryological development we can turn to the bones of the foot and ankle.

Fig. 2.—Stages in the embryological development of the big toe joint shown diagrammatically. Fully developed joint and periarticular structures. Stage 1, a and b. Undifferentiated mass of mesenchymal cells which become condensed in the region of the future joint. Stage 2, c. By a process of liquefaction or separation, a transverse cleft is produced which, at a later stage, forms the joint cavity. Stage 3, d. By a process of selective differentiation some of the cells adjoining the cleft are transformed into: Articular cartilage cells. Capsule cells. Synovial cells. This is a reversible process.

Tibia.—The diaphysis of the tibia shows its ossifying center toward the close of the eighth, or early in the ninth, week. During the eleventh week a fine, irregular medullary cavity develops. The proximal epiphysis usually appears during the thirty-ninth or fortieth week, just before birth.

Fibula.—The description of the fibula is essentially identical to that of the tibia.

Bones of Foot.—The os calcis is the first tarsal bone to ossify. This occurs during the twenty-first week (fifth fetal month) or slightly later. The center for the astragalus appears in the twenty-fourth week, or as late as the thirty-second week. The centers for the cuboid bone are not discernible until the fortieth week, but may not be seen

until after birth. The ossification of this bone is sometimes used to determine fetal maturity.

Ossifying centers begin to appear in the phalanges during the ninth week. The first center is that of the diaphysis of the terminal phalanx of the great toe. The centers for the diaphyses of the metatarsal bones of the second and third toes follow almost immediately. At the tenth week, ossifying centers appear in the terminal phalanges of the second and third toes, and occasionally the fourth. At the thirteenth week, the terminal phalanx of the fifth toe may show a center, as well as the basal phalanges of all the toes. At the twentieth week, the center for the middle phalanx of the second toe appears, but this may be delayed until the twenty-first or twenty-fourth week. At the twenty-first week, the centers for the middle phalanx of the second and third toes appear, and in the twenty-ninth week, that for the middle phalanx of the fourth toe is seen. From the thirty-third to the thirty-sixth weeks, the center for the middle phalanx of the little toe may be seen.

During the third month the nails begin to form, starting at the ends of the toes and gradually moving dorsally.

The individual muscles begin to differentiate at the sixth week. An offshoot from the extensors of the toes and the tibialis anterior becomes the peroneal muscle groups. The extensor hallucis longus muscle splits off from the same mass which is to give rise to the extensor muscles. By the seventh week most of the muscles have become differentiated.

In about the twelfth week the foot begins to dorsiflex at the ankle From this position, the alterations consist in rotation from supination to pronation.

Embryological developmental defects are common. Some of the more frequent are club-feet, supernumerary toes, overriding and underriding toes, metatarsus varus, giantism of the foot or parts thereof (such as toes). Absence of the tibia, fibula, or any number of toes is frequently seen. Absence of the entire foot and ankle is a rare defect. Congenital fusion of various bones is described in Chapter V.

ANATOMY OF THE ANKLE

A basic knowledge of anatomy is imperative in order that the physiology, mechanics, or pathology of the foot and ankle can be adequately understood.

The ankle joint consists of the tibia and fibula proximally, the astragalus distally, and the structures around it. Callander considers the surgical anatomy of this region under two headings: (1) structures about the anterior region of ankle; and (2) structures about the

posterior region of the ankle The malleoli divide the anterior from the posterior regions

A thin capsule surrounds the articular surfaces of the ankle bones

The group of ligaments that radiate from the medial malleolus to the talus, calcaneus and navicular, constitutes the deltoid ligament It consists of the anterior and posterior talo-tibial, the calcaneo-tibial and the tibio-navicular ligaments The first of these passes to the anterior part of the neck of the talus and is covered by the calcaneo-tibial This is attached to the border of the sustentaculum tali, while the posterior talo-tibial goes to the posterior process of the talus and the tibio-navicular to the dorsal surface of the navicular

Three ligaments pass from the lateral malleolus to the talus and calcaneus, the anterior and posterior talo-fibular and the calcaneo-fibular The first of these runs almost horizontally from the anterior surface of the malleolus to the anterior border of the trochlea of the talus, the second, also horizontal, passes to the lateral tubercle of the posterior process of the talus, and the calcaneo-fibular passes obliquely downward and backward to the lateral surface of the calcaneus

The talo-calcaneal articulation is situated between the posterior articular surface of the calcaneus and the posterior calcaneal facet of the talus The latter is concave, the former convex Occasionally, the joint cavity communicates with the ankle joint

The talo-calcaneo-navicular articulation is found between the head of the talus and the anterior and middle articular surfaces of the calcaneus, the posterior surface of the navicular and the navicular fibrocartilage in the plantar calcaneo-navicular ligament The socket for the head of the talus is thus formed by four different cartilage-covered surfaces It is a composite joint, being a combination of the anterior and middle talo-calcaneal and the talo-navicular articulations

The ligamentous connections of the talus and calcaneus are, firstly, the interosseous talo-calcaneal ligaments, which fill the sinus tarsi, and secondly, reinforcing ligaments of the posterior and anterior talo-calcaneal ligaments The lateral and anterior ligaments, which bridge over the sinus tarsi, are united with the interosseous ligament The posterior one extends between the lateral tubercle of the posterior process of the talus and the upper surface of the calcaneus The medial ligament passes from the tubercle of the talus to the sustentaculum tali

The lateral malleolus is very superficial Anterior to it, and lateral to the tendon of the peroneus tertius, is a depression which indicates the level of the ankle joint There is a similar depression between the medial malleolus and the tibialis anterior tendon These areas may bulge, or at least the depression may flatten out when intra-articular pathologic changes are present

The medial surface of the head of the astragalus can be palpated by pressing on the resistant surface immediately in front of it. The tendon of the flexor digitorum longus crosses the medial aspect of the sustentaculum tali of the calcaneus, which can be felt just below the medial malleolus. The plantar surface of the sustentaculum is grooved by the flexor hallucis longus tendon. The tendon of the tibialis anterior becomes very prominent when the foot is dorsiflexed and inverted and can be traced to its medial insertion into the first metatarsal and adjoining cuneiform bones. The extensor digitorum communis tendon and the extensor hallucis longus tendon can easily be seen while the foot is in this position. The dorsalis pedis artery can be felt pulsating as it becomes superficial just below the fascia cruris, on the dorsum of the ankle. The internal saphenous vein can be recognized as it ascends in front of the medial malleolus, after arising from the venous arch at the dorsum of the foot.

In the posterior region of the ankle, the calcaneus tendon is the main structure. The groove in the calcaneus, lateral to the tendo Achillis, contains the tendons of the peronei longus and brevis, which are bound down by the external annular ligament. The peroneus brevis is the deeper of the two and inserts into the prominent tuberosity at the base of the fifth metatarsal. The peroneus longus tendon passes forward and downward to the lateral margin of the foot beneath the trochlear process and curves around the lateral border of the cuboid. It crosses the sole at an angle, forward and medially, and inserts at the base of the first metatarsal bone.

The internal annular ligament passes from the medial malleolus to the calcaneus. The tendons of the tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles and the posterior tibial vessels pass under it. The tibialis posterior tendon lies against the back of the malleolus and extends to the medial margin of the foot, inserting into the tuberosity of the navicular. The posterior tibial vessels and nerve are located between the flexor digitorum longus and the flexor hallucis longus tendons. There is a wide space filled with fatty areolar tissue between the calcaneus tendon and the posterior tibial vessels, so that there is little risk of damaging these vessels when operating on the tendon.

The deep fascia is an important supporting structure which keeps the tendons in contact with the bones and forms osteo-aponeurotic canals through which the tendons and their sheaths glide.

Arteries of the Ankle.—The anterior tibial artery is crossed by the extensor hallucis longus tendon just proximal to the ankle joint. It is continued into the dorsalis pedis beyond the level of the joint. It lies between the extensor hallucis longus and the extensor digitorum longus muscles. Malleolar branches are given off about the ankle.

The posterior tibial artery can be felt pulsating between the medial malleolus and the heel It terminates in the medial and lateral plantar arteries The medial side of the heel receives branches from the lateral plantar branch as well as from the main artery

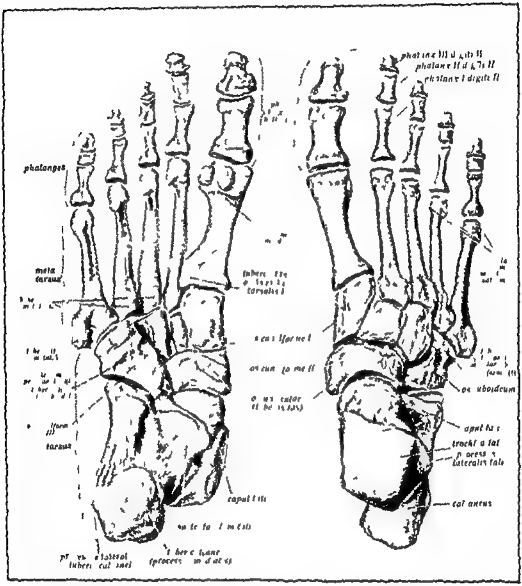


FIG 3 —Bones of the foot plantar and dorsal views (Sobotta and McMurrich Atlas of Human Anatomy courtesy of J F Lehmanns)

The peroneal artery lies deep, and its anterior branch crosses the ankle joint in front of the interosseous ligament between the tibia and fibula This artery has anastomotic connections with branches from the anterior and posterior tibial arteries about the ankle and heel

Bones and Joints of the Ankle —The ankle joint is formed by the lower ends of the tibia and fibula articulating with the astragalus However, these bones are so intimately related with the tarsal bones

and joints in the mechanics and alignment of the ankle joint, that it is improper to isolate the ankle from the foot in a discussion of the anatomy of this region.

The distal tibiofibular joint is composed of the convex fibular surface and the concave tibial surface, without an articular cartilage intervening.

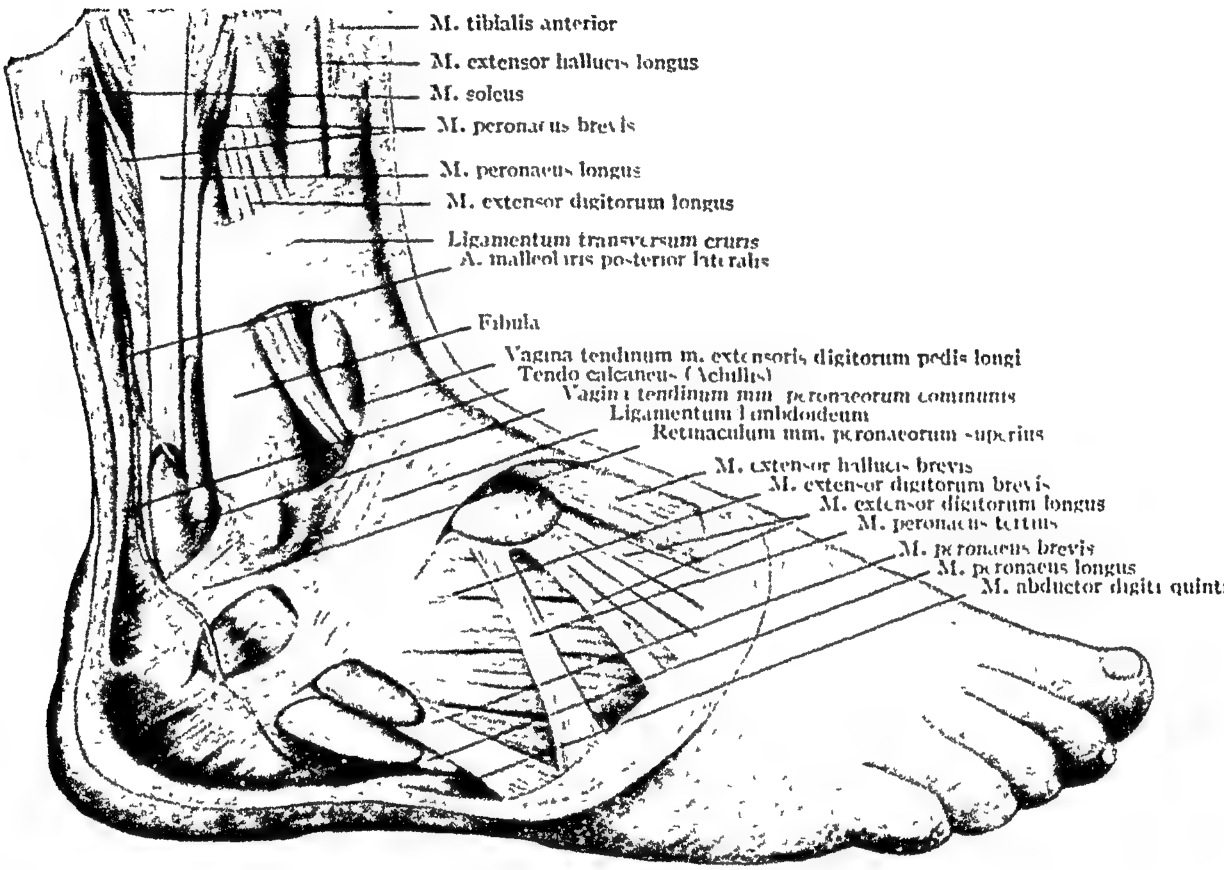


FIG. 4.—Superficial structures of the antero-external region of the ankle and foot. (Callander's Surgical Anatomy, courtesy of W. B. Saunders Company.)

The superior, or trochlear, surface of the astragalus articulates with the tibia and is secured on each side by the malleoli, to give the necessary stability to the ankle joint. When the foot is extended, the narrow posterior part of the upper surface of the astragalus lies rather loosely in the mortise formed by the malleoli and allows a small amount of movement from side to side.

Ligaments of the Ankle.—The capsular ligament is a weak structure, especially anteriorly and posteriorly. The anterior ligament is a thin membrane attached to both malleoli, to the lower extremity of the tibia, and to the neck of the astragalus. The posterior ligament is very weak and consists of only a few ligamentous bands extending from the inferior surface of the tibia and a posterior tibiofibular liga-

ment, to the posterior aspect of the astragalus The ankle joint receives strong support posteriorly from the flexor hallucis longus tendon

The medial and lateral sides of the joint are strongly reinforced by the deltoid ligament medially and the lateral ligament The deltoid, or internal lateral ligament is a fan-shaped sheet of ligamentous fibers, originating on the medial malleolus and attaching to the navicular, astragalus, sustentaculum tali, and to the calcaneonavicular ligament The tendons of the tibialis posterior and flexor digitorum longus muscles reinforce it The lateral ligament has three main bands The

FIG 5 —Superficial structures of the anteromedial region of the ankle and foot (Callander s Surgical Anatomy courtesy of W B Saunders Company)

anterior band stretches from the lateral malleolus to the lateral surface of the neck of the astragalus The medial band, or calcaneofibular ligament, extends from the malleolus to the lateral surface of the calcaneus The posterior band, or talofibular ligament, rigidly binds the fibula and talus

ANATOMY OF THE FOOT

The foot is constructed to withstand repeated shocks and sudden movements *Callander states this has been accomplished by the fact*

that its "constituent bones are short, solid and well integrated into a double arch, joined by strong ligaments and supported by powerful tendons."

Tendons.—The tendon of the tibialis anterior muscle inserts into the first cuneiform and the base of the first metatarsal bone. Its

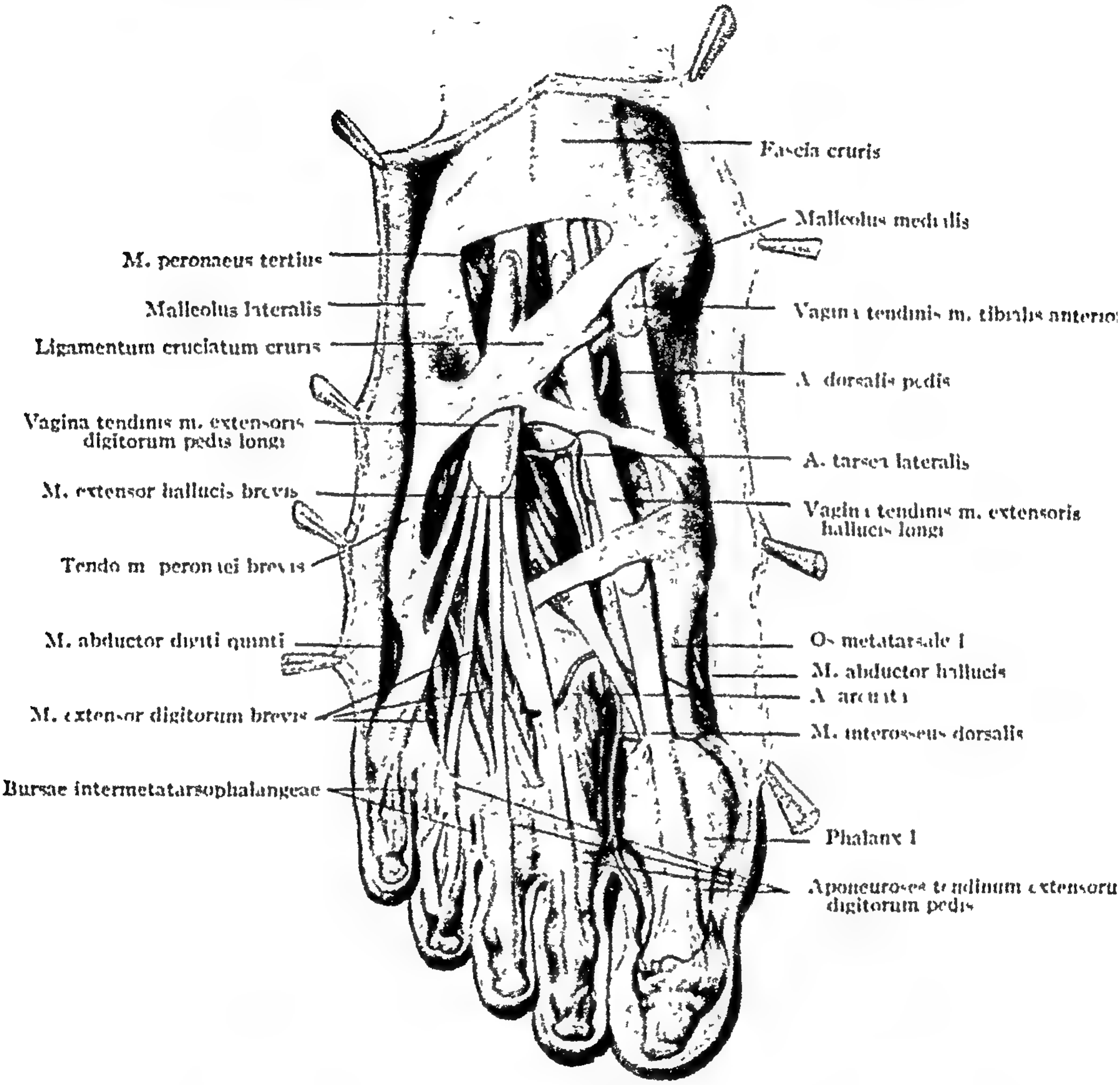


Fig. 6.—Superficial structures about the anterior region of the ankle and the dorsal region of the foot. (Callander's Surgical Anatomy, courtesy of W. B. Saunders Company.)

course has previously been described. The extensor hallucis longus tendon lies in front of the ankle and passes forward, inserting on the dorsal aspect of the big toe. The tendons of the extensor digitorum longus muscle are directed to the four outer toes. The extensor digitorum brevis tendon can be felt on the posterolateral aspect of the dorsum of the foot. The peroneus brevis tendon passes forward under the

lateral malleolus to insert into the tuberosity of the fifth metatarsal bone The various actions of the foot and ankle with the muscles and tendons involved, follows

Action	Muscles
Dorsiflexion	Tibialis anterior, extensor digitorum longus, peroneus tertius, extensor hallucis longus
Plantar flexion	Gastrocnemius, tibialis posterior, flexor digitorum longus, soleus, peroneus brevis, flexor hallucis longus, peroneus longus
Adduction	Tibiales posterior and anterior
Abduction	Peronei longus, brevis, tertius
Inversion	Tibiales anterior and posterior
Eversion	Peronei tertius, brevis, longus

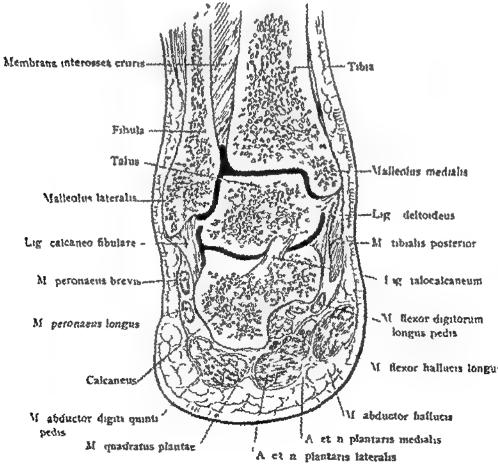


Fig 7—Frontal section through the ankle joint (Eycleshymer and Jones)

The plantar aponeurosis consists of a strong central band and two weaker lateral bands The intrinsic muscles of the sole arise from it,

and in addition it serves to protect the soft tissues between it and the bones. The strong central band helps to support the longitudinal arch.

Blood-vessels and Nerves.—The veins on the dorsum of the foot are arranged in the shape of a fan and are usually visible. The large and small saphenous veins arise from the marginal veins of this group. The dorsalis pedis artery runs from mid-way between the malleoli to the

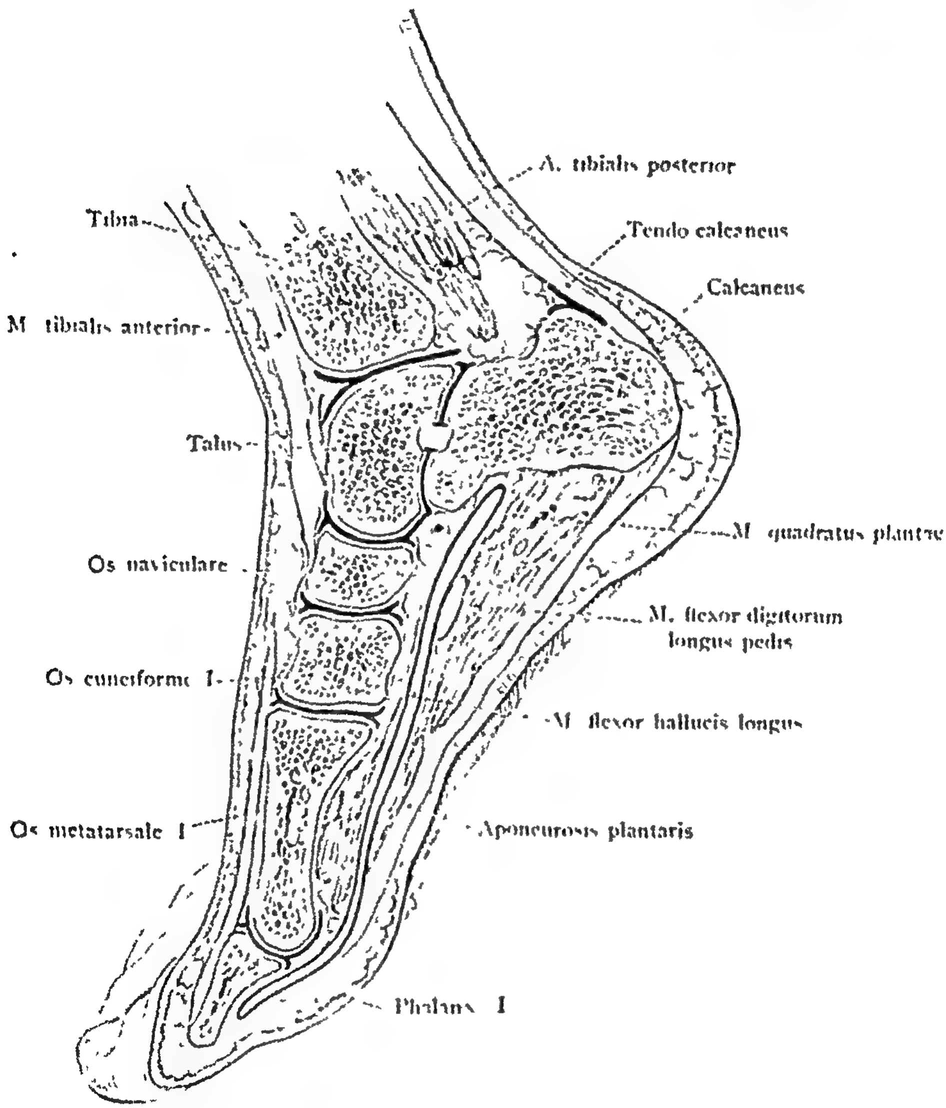


FIG. 8.—Sagittal section of the foot and ankle passing through the great toe (Eycleshymer and Jones.)

first interosseous space. It is a continuation of the anterior tibial artery. The anterior tibial nerve runs along the lateral side of the artery.

The plantar vessels and nerves are found beneath the aponeurotic fascia. The posterior tibial artery divides into the lateral and medial plantar arteries. The medial plantar artery passes forward between the abductor hallucis and the flexor digitorum brevis muscles. Its

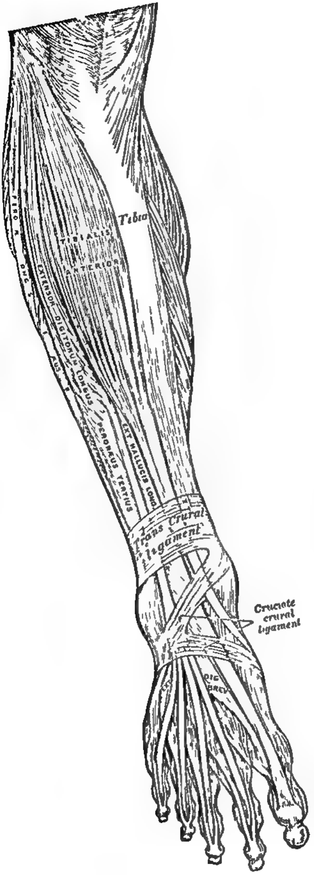


FIG 9 —Muscles of the front of the leg. (Gray's Anatomy)

terminal branches communicate with the digital arteries. The lateral plantar artery lies beneath the flexor digitorum muscle, anterior and lateral to the base of the fifth metatarsal bone, where it turns

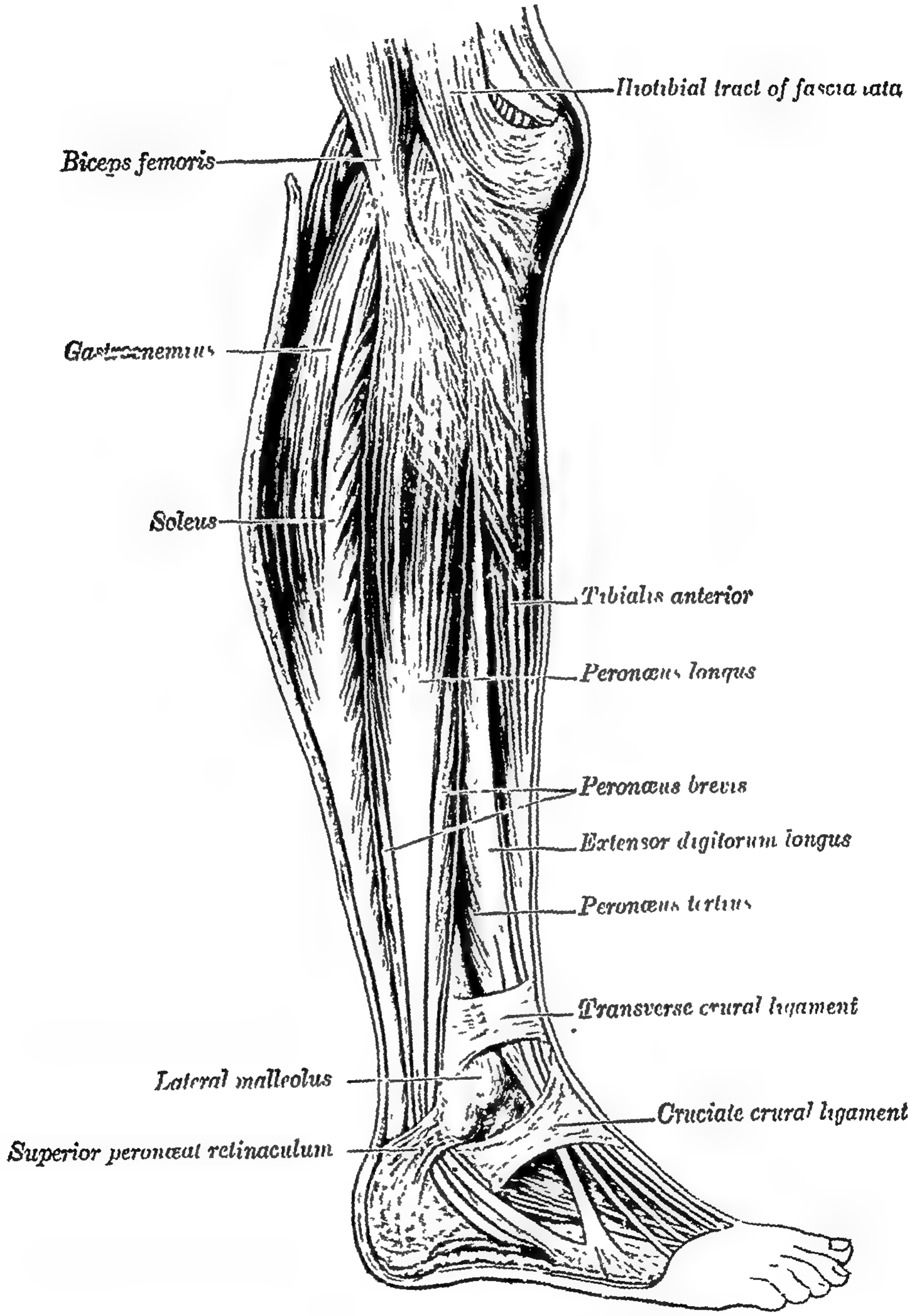


FIG. 10.—The right lateral crural muscles. (Gray's Anatomy.)

medially and becomes the plantar arterial arch, extending over the bases of the middle three metatarsal bones. Its terminal branch turns dorsally in the first metatarsal space to communicate with the dorsalis pedis artery.

The medial plantar nerve originates in the fourth and fifth lumbar and first sacral nerves and arises from the tibial nerve It supplies a large cutaneous area, but only a few muscles The *lateral plantar* nerve arises from the tibial nerve and accompanies the lateral plantar *artery to the plantar arterial arch* It has a small cutaneous distribution but supplies most of the muscles of the sole

Bones and Joints of the Foot —The bones of the foot form two longitudinal groups, a medial and a lateral *The medial group, which* receives most of the body weight thrust through the tibia, consists of the astragalus, scaphoid, three cuneiforms, three medial metatarsal bones, and three medial toe phalanges The lateral group is composed of the calcaneus, cuboid, and the two lateral metatarsal bones and their phalanges

The talocalcaneal and the talonavicular joints are the only joints in the foot in which considerable movement takes place What is usually called the subastragalar joint (talo-calcaneonavicular joint) is a large articular region between the talus above and the calcaneus and navicular below and in front *The talonavicular segment of this articulation* is of the ball-and-socket variety The lower part of the head of the talus articulates with the spring ligament (plantar calcaneonavicular), the latter being important in maintaining the longitudinal arch The mid-tarsal joint is supported by the long and short plantar ligaments *which separate the posterior and anterior parts of the foot*

The longitudinal arch is made up of medial and lateral columns The medial column consists of the calcaneus, talus, navicular, the three cuneiforms, and the three medial metatarsal bones The lateral column consists of the calcaneus, the cuboid, and the two outer metatarsal bones

The transverse arch is wedge-shaped because of the contour of some of its bones, namely, the middle and lateral cuneiforms and the second, third, and fourth metatarsals When it gives way the metatarsal heads are lowered, causing pain and in some cases the formation of calluses

CHAPTER II

PHYSIOLOGY AND BIOMECHANICS OF THE FOOT AND ANKLE

THE functions of the foot and ankle are weight-bearing and flexible locomotion. These parts of the lower extremity furnish spring to the step, which prevents jars to the brain, spinal cord, and abdominal and pelvic organs. Integrity of structure and function are not necessarily identical. A perfectly normal looking foot may not function normally, and conversely an imperfect looking foot may give a perfect performance.

Functional disturbances involve mechanical stress and strain on muscles, ligaments, capsules, bones, and joints. Two bones of great importance are the astragalus and os calcis. The astragalus is of importance because it is the mortise bone between the leg and the foot. It articulates with the tibia, fibula, and scaphoid, and moves on the os calcis in three places. Although it cannot move itself, because it has no muscle attachments, it is subjected to the superincumbent weight of the entire body. The os calcis is important because of the attachment to it of the Achilles tendon and plantar fascia and because it furnishes the initial bearing surface as the foot strikes the ground in walking. The scaphoid and first cuneiform bones owe their importance to the attachment of ligaments and especially of the tendons of the peroneus longus and the anterior and posterior tibial muscles. The longitudinal arch is composed of the os calcis, astragalus, scaphoid, first and second cuneiforms, the first metatarsal, and the proximal phalanx of the great toe. When a foot is in action it is supported chiefly by muscles, but when standing it is supported mainly by ligaments. Hoke emphasized the importance of three tendons, *viz.*, the anterior and posterior tibials and the flexor hallucis longus.

BIOMECHANICS OF THE FOOT AND ANKLE

According to Hoke, the human foot can be held up in an arched position only by the power of muscles acting coördinately the instant weight is borne, presupposing that there is nothing to hinder the component bones from taking a normal position, and that the Achilles tendon is not short. The mechanism of this is as follows:

Figure 15 is drawn from a lateral roentgenogram of a normal foot taken while the person is standing. The body weight—arrow "A"—is applied to the astragalus at the lower end of the tibia. This weight

force splits into component forces "B" and "C". Force "C" is transmitted to the os calcis, and although it has little flattening effect, it tends to produce heel pronation. Force "B" is transmitted forward in the direction of the axis of the neck of the astragalus, and is applied at the head of this bone to the scaphoid and the calcaneo-scaphoid ligament. The astragalo-scaphoid and the subastragalar joints are the movable areas which permit flattening of the foot, and at the same time stretching of the ligaments in the mid-tarsal joints, if force "B" is not checked by the coordinate action of the power of the tibialis posticus, tibialis anticus, and flexor hallucis longus muscles. The tibialis posticus pulls in the direction of the arrow "D"—opposite the force "B". The function of this muscle is to adduct the foot

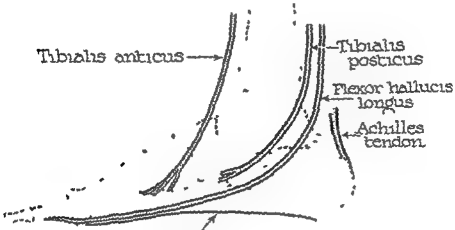


FIG 11.—The four most important tendons of the foot and ankle. The most important muscles, represented here by their tendons, are the tibialis anticus, which we see coming down along the inner border of the foot, the tibialis posterior winding around the medial malleolus, the flexor hallucis longus, and the most important tendon in the body, the achilles tendon. The plantar fascia is an important structure. In the special exercises the aim is to strengthen the muscles that do their work through these tendons

and to hold the scaphoid bone tightly against the head of the astragalus and the scaphoid tubercle, somewhat under the head of the astragalus, the latter bone being bevelled underneath to permit this. The tibialis anticus is attached to the skeleton anterior to the scaphoid-cuneiform joint and pulls upward—arrow "E". One might ask, "How does the tibialis anticus oppose the force 'B'?" It does this by lifting the bone lever made up of the scaphoid and internal cuneiform bones. But this power, used in this way, can be effective only if the tibialis posticus holds the scaphoid tightly against the head of the astragalus, the scaphoid tubercle somewhat under it, and if the scaphoid-cuneiform joint is a tight joint permitting only a little movement. If the foot, when weight is borne upon it, is only mod-

erately abducted and the scaphoid-cuneiform joint is loose, the effective arch-lifting power of the tibialis anticus is markedly decreased. . . . The flexor hallucis longus opposes the force "B" and helps to hold up the arch. Its tendon, winding under the sustentaculum tali, using this for a fulcrum, courses under the inner row of bones analogous to a string to a bow, and when it is taut, lifts the arch.

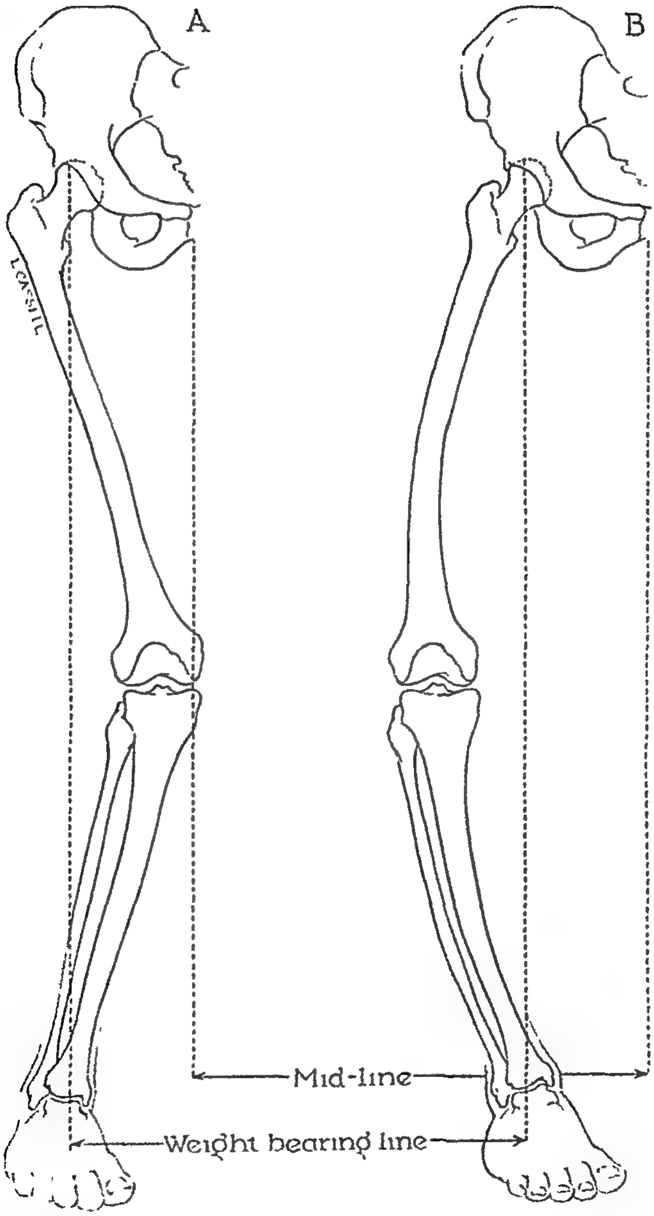
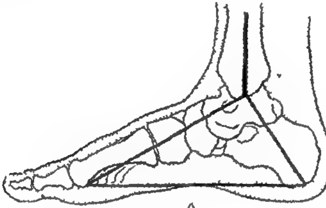


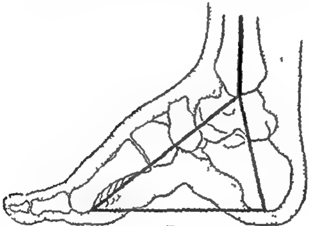
FIG. 12 —Diagrammatic representation of knock knee and bow leg. Right side.

The mechanical details of this follow: When the great toe is pressed against the sole of the shoe by the flexor muscle, it sends a force "F" up the shaft of the first metatarsal bone. On the inferior surface of

the posterior end of that bone there is a tubercle which is directed downward When the toe is flexed, the tubercle impinges against the internal cuneiform bone From this point of contact the tuberous border of the internal cuneiform winds inward and upward The force "F" is transmitted to the scaphoid, the tubercle of which is directed inward The spiral arrangement of these tubercles converts the force "F" into a torque, which finally acts in the direction of "F", marked on the scaphoid This force is markedly decreased if



A



B

FIG 13 —*A* Illustrating lines of stress and strain on normal foot *B* In a case of pes cavus Note the components of the weight bearing the heights of the longitudinal arches the distances from each os calcis to the head of the first metatarsal

there is a great deal of movement in the scaphoid-cuneiform and internal-middle cuneiform joints There can be no mechanical substitutes for the power of these three muscles In order to hold up the arch, these three muscles—the tibialis posticus, tibialis anticus, and flexor hallucis longus—must be tightened simultaneously the instant the foot strikes the ground when walking If this is not done, the astragalus tilts downward and the force "B", not properly resisted, puts all the strain upon the mid-tarsal segment of the foot, the liga-

ments are stretched more and more, and ultimately the joints are too loose for the muscle power to be effective, even if used coördinately.

One more factor completes the vicious circle in the development of the flexible flat-foot. If the foot is used in an abducted position for years, the Achilles tendon is not stretched at each step. Gradually it becomes shortened to such a degree that the astragalus is permanently tilted downward.

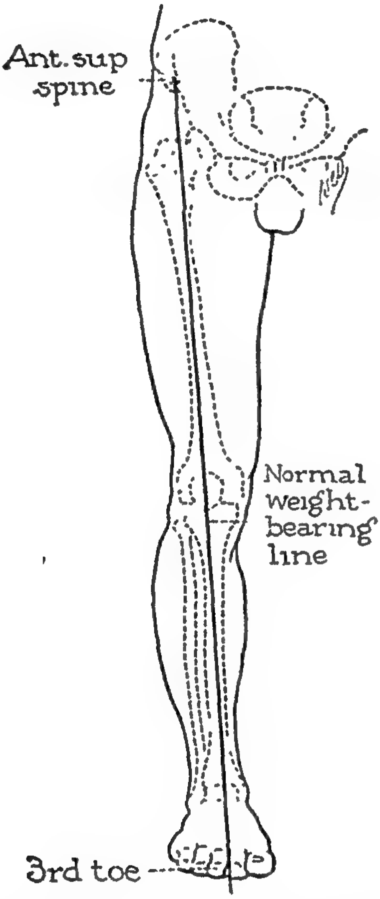


FIG. 14.—Weight-bearing line of leg. (Magnuson's Fractures, courtesy of J. B Lippincott Company.)

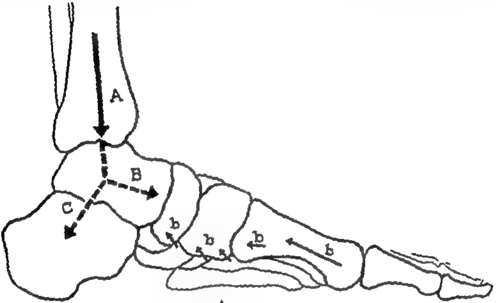
Weight-bearing Lines.—Normally, a plumb line dropped from the middle of the patella falls through the middle of the astragalus and a point between the bases of the first and second toes, and a line drawn through the middle of the great toe and continued backward passes through a central point in the heel. The latter is known as "Meyer's line."

Terminology.—The generic term for foot deformities is "talipes" which is derived from talus (astragalus) and pes (foot). If the toes are at a lower level than the heel, the term "equinus" is used. If the heel is lower than the toes, the condition is described by the term "calcaneus." If, in addition to either of these positions, the foot is

rotated on the long axis of the foot, the terms "varus" and "valgus" are used

Metatarsus varus = "pigeon toes"

"Pes cavus" means hollow foot, and "pes cavus pronatus," a high arched foot that is pronated "Pes planus" or valgus is flat-foot



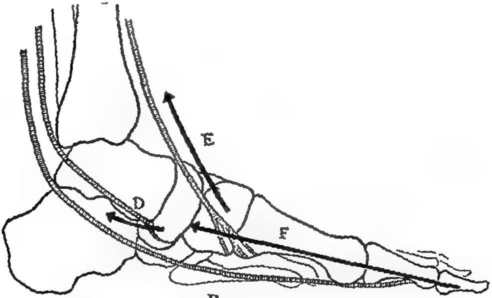


FIG 15 —Hoke's conception of lines of stress and strain at the ankle and foot *A* Weight bearing thrust which divides into *B* and *C* components *b* *b* *b* *b* indicate backward thrusts which are described under *B* *D* represents posterior tibial tendon *E* indicates anterior tibial tendon *F* represents flexor hallucis longus tendon

"Inversion" of the foot occurs when the inner border is elevated, and "eversion" when the outer border is elevated When a foot is

inverted, its forepart tends to approach the mid-line of the body. This movement, called "adduction," occurs chiefly at the tarsometatarsal articulations. With eversion, there is a strong inclination toward the opposite movement at these joints, namely, "abduction." When a foot is everted and adducted, there is usually an upward and outward rotation of the medial bones of the mid-tarsal region, namely, the scaphoid and the first and second cuneiform bones. This constitutes "supination." If a foot is everted and abducted, the reverse occurs, that is downward and inward rotation of the medial mid-tarsal bones, *i. e.*, "pronation." A foot that is inverted, adducted, and supinated is in varus position, whereas a foot that is everted, abducted, and pronated is in valgus position. The following table will be found useful in remembering these terms:

Inversion	Adduction	Supination	Varus
Eversion	Abduction	Pronation	Valgus

The following outline is helpful in classifying foot deformities:

Talipes
- Equino
  - Varus
  - Valgus
- Calcaneo
  - Varus
  - Valgus

CHAPTER III

BASIC PRINCIPLES OF FOOT AND ANKLE DISTURBANCES

Etiology —The causes of foot and ankle troubles include race, age, sex, hereditary, congenital, traumatic, infectious, neurogenic, myogenic, circulatory, metabolic, arthritic, nutritional, endocrinogenic dermatologic, allergic, climatic, geographic and neoplastic factors For example, in cases of club-foot, it is necessary to consider congenital

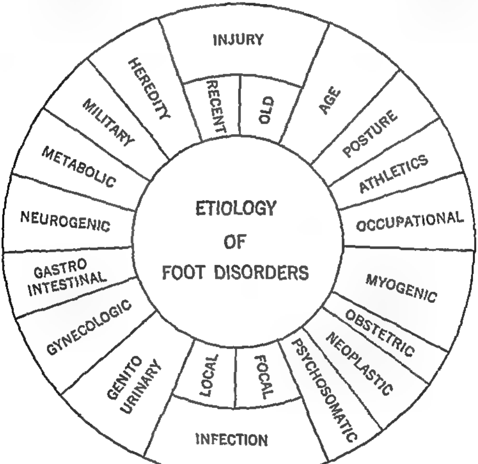


Fig 16

factors, in syphilis, hereditary sources, in fractures, trauma, in infection, tuberculosis, in poliomyelitis, neurogenic damage, in thromboangiitis obliterans, circulatory disturbances, in osteo-arthritis, metabolic causes, and in rickets, nutritional deficiencies Various etiological factors may produce similar symptoms and pathological changes

The sex incidence of certain conditions is interesting. For example, over 90 per cent of cases of Buerger's disease occur in men, whereas over 90 per cent of cases of Raynaud's disease occur in women. Gout is more common in men. Hemophilia occurs only in males.

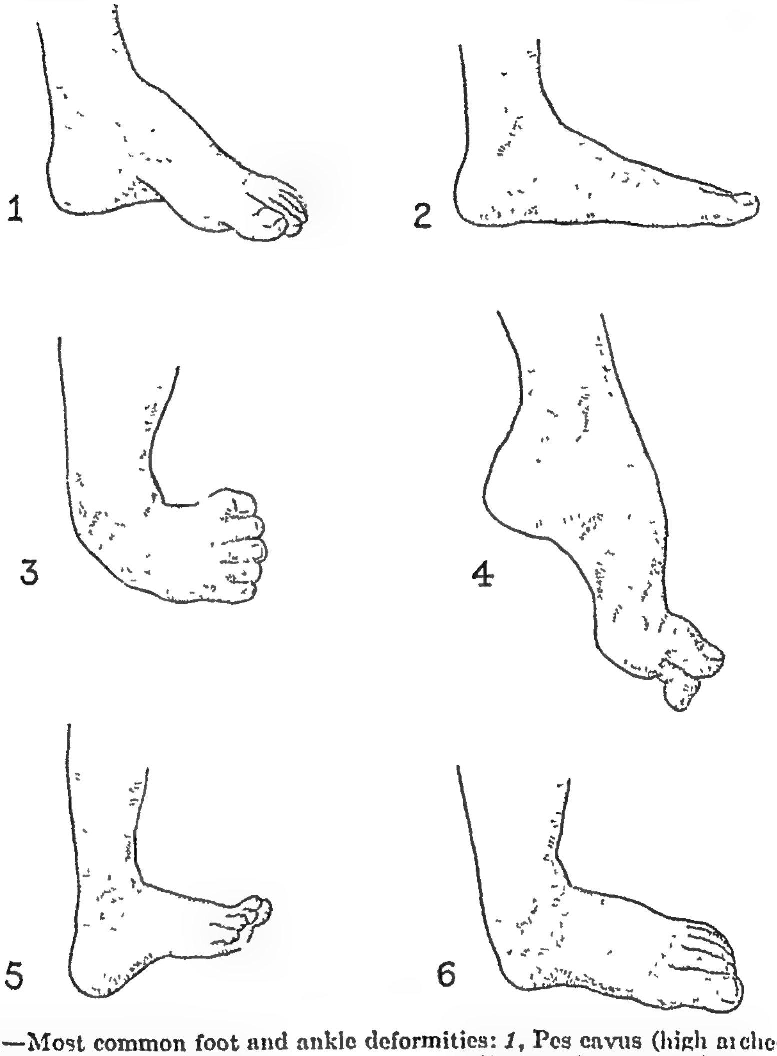


FIG. 17.—Most common foot and ankle deformities: *1*, Pes cavus (high arched foot); *2*, Pes planus (flat foot), *3*, Talipes equino varus; *4*, Talipes equinus; *5*, Talipes calcaneus; *6*, ankle valgus. If a foot is turned inward, it is inverted, if it is turned out, it is everted. Most strains are inversion sprains. It is easy to see, when the foot is inverted the tendency is for the foot to turn toward the middle line of the body. When you invert and adduct, the midtarsal region comes up and that is supination. When the foot is everted it tends to abduct, the midtarsal goes down and that position is pronation.

Trauma, or injury, may be acute or continued, mild or severe. The feet of the ballet dancer are subjected to mild, continued trauma. Severe, continued trauma occurs during certain occupations and following injuries. The continued use of a foot and ankle in a poor mechanical position produces pain and disability. Every movement of a joint causes trauma. If the circulation is good, the effects of the trauma are repaired immediately. If repair does not progress as

rapidly as destruction, a pathological condition results If the circulation is impaired, the defect is not repaired and a lesion is formed The balance between wear and repair is dependent upon an adequate vascular response to function

Lesions and Defects of the Foot and Ankle

1 Congenital
- Club-foot
- Pigeon toe
- Syndactylism
- Overriding toes
- Underriding toes
- Macrodactyly—giantism
- Supernumerary toes
- Absence of toes
- Wide metatarsal arch—splay foot
- Small feet—large body

2 Traumatic
- Fractures
- Dislocations
- Soft tissues
  - Sprain
  - Rupture
  - Wounds
  - Burns

3 Infectious
- Pyogenic infections
- Tuberculosis
- Syphilis
- Unusual infections

4 Mechanical Static
- Flat foot
- Metatarsal depression
- Pes cavus
- Hammer toe
- Bunion
- Bunionette
- Hallux valgus
- Hallux rigidus

5 Paralytic
- Poliomyelitis
  - Infants
  - Children
  - Adults
- Spastic paralysis
  - Infants
  - Adults
- Diphtheritic paralysis

6 Neurogenic
- Tumors of spinal cord
- Hysteria

7 Arthritis—Gout

8 Circulatory—Vascular and Hematological

9 Metabolic—Nutritional

10 Glandular

11 Growth disturbances

12 Epiphysitis—Osteochondritis

13 Dermatological lesions—Mycotic lesions

14 Occupational—Industrial—Military

15 Tumors
- Bone and joint
- Soft tissues

16 Psychosomatic

The sex incidence of certain conditions is interesting. For example, over 90 per cent of cases of Buerger's disease occur in men, whereas over 90 per cent of cases of Raynaud's disease occur in women. Gout is more common in men. Hemophilia occurs only in males.

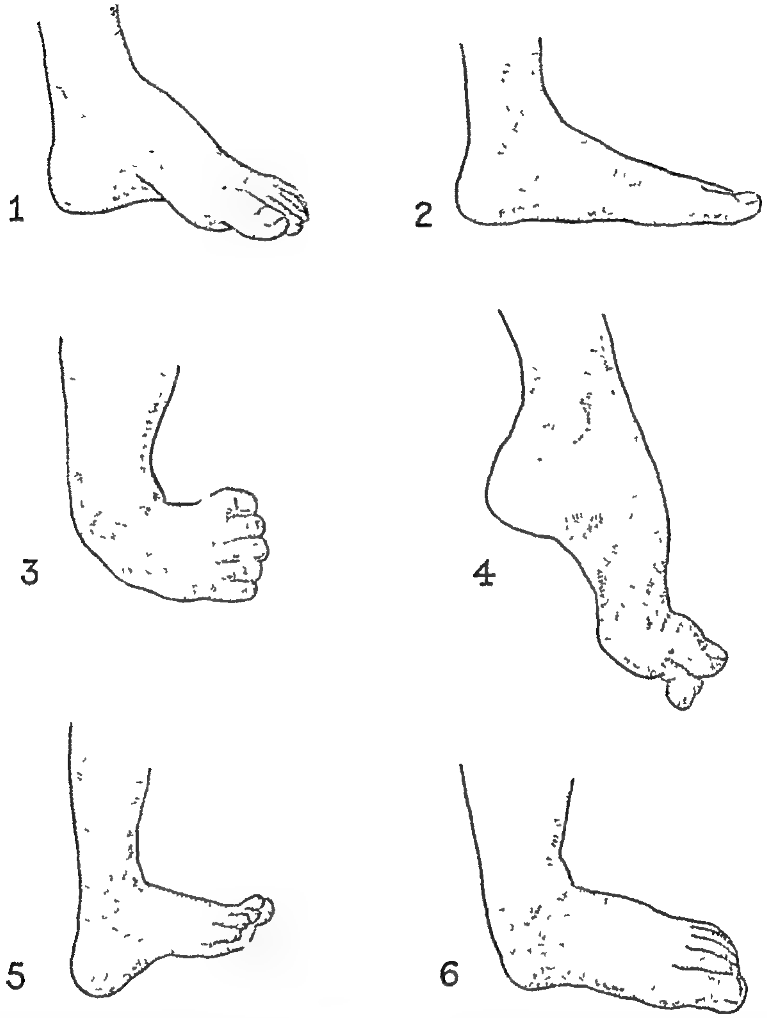


Fig. 17.—Most common foot and ankle deformities: *1*, Pes cavus (high arched foot); *2*, Pes planus (flat foot); *3*, Talipes equino varus; *4*, Talipes equinus; *5*, Talipes calcaneus; *6*, ankle valgus. If a foot is turned inward, it is inverted, if it is turned out, it is everted. Most strains are inversion sprains. It is easy to see, when the foot is inverted the tendency is for the foot to turn toward the middle line of the body. When you invert and adduct, the midtarsal region comes up and that is supination. When the foot is everted it tends to abduct, the midtarsal goes down and that position is pronation.

Trauma, or injury, may be acute or continued, mild or severe. The feet of the ballet dancer are subjected to mild, continued trauma. Severe, continued trauma occurs during certain occupations and following injuries. The continued use of a foot and ankle in a poor mechanical position produces pain and disability. Every movement of a joint causes trauma. If the circulation is good, the effects of the trauma are repaired immediately. If repair does not progress as

rapidly as destruction, a pathological condition results. If the circulation is impaired, the defect is not repaired and a lesion is formed. The balance between wear and repair is dependent upon an adequate vascular response to function.

Lesions and Defects of the Foot and Ankle

1	Congenital	Club-foot	
		Pigeon toe	
		Syndactylism	
		Overriding toes	
		Underriding toes	
		Macrodactyly—giantism	
		Supernumerary toes	
		Absence of toes	
		Wide metatarsal arch—splay foot	
		Small feet—large body	
2	Traumatic	Fractures	Sprain
		Dislocations	Rupture
		Soft tissues	Wounds
			Burns
3	Infectious	Pyogenic infections	
		Tuberculosis	
		Syphilis	
		Unusual infections	
4	Mechanical Static	Flat foot	
		Metatarsal depression	
		Pes cavus	
		Hammer toe	
		Bunion	
		Bunionette	
		Hallux valgus	
		Hallux rigidus	
5	Paralytic	Poliomyelitis	Infants
			Children
			Adults
		Spastic paralysis	Infants
			Adults
		Diphtheritic paralysis	
6	Neurogenic	Tumors of spinal cord	
		Hysteria	
7	Arthritis—Gout		
8	Circulatory—Vascular and Hematological		
9	Metabolic—Nutritional		
10	Glandular		
11	Growth disturbances		
12	Epiphysitis—Osteochondritis		
13	Dermatological lesions—Mycotic lesions		
14	Occupational—Industrial—Military		
15	Tumors	Bone and joint	
		Soft tissues	
16	Psychosomatic		

Most Common Medical Causes
Arthritis Gout Infections
Most Common Surgical Causes
Infections Flat feet Hallux valgus Infantile paralysis Bursitis Calcaneal spurs Tuberculosis Tumors
Congenital Causes
Club-foot Spina bifida
Bone Lesions
Osteomyelitis Fractures Dislocations Tumors
Organic Neurological Causes
Infantile paralysis Spastic paralysis Spina bifida Spinal cord tumors Disk syndrome Neuritis
Psychosomatic Causes
Arthritis Hysteria Exaggeration

Mild trauma may produce sprain or strain; continued trauma may produce a tear, displacement, dislocation, or fracture. Trauma may be the only etiological factor, a precipitating factor, or a factor that exaggerates a preëxisting condition.

Ligaments do not withstand continuous strain as well as muscles. According to Keith's law, ligaments are never used for the continuous support of any joint or part. If the muscles on the inner border of the foot and ankle give way, the strain falls upon the medial ligaments;

these ligaments lengthen, as do all unsupported structures subjected to continuous strain, and flat-foot or ankle valgus may result

The primary cause of static deformities of the foot and ankle is a defect or change in the osseous system, but the structures immediately responsible for the deformity are the muscles around the joint In the rachitic child the muscles are flabby and have lost some of their reflex tone Because of this condition, the ligaments of the joints have a static muscular function thrust on them and deformity results The electrical irritability of the muscles is also diminished The reflex tone of a muscle depends on its state of tension, which depends in turn on the rigidity of the bone upon which the muscle acts

Fatigue and infection bear a close relationship to each other Sir James Paget said, "Fatigue has a larger share in the promotion or transmission of disease than any other causal condition"

Foot disabilities occur frequently during the treatment of non-orthopedic conditions, such as infectious and contagious diseases, pneumonia, and kidney and heart lesions The effects of prolonged recumbency are frequently reflected in the foot and ankle Immobilization by braces, casts, and other agents may also affect the foot When one foot, knee, or hip is out of order, the other is subjected to overactivity, stress, and strain When one leg is amputated, the remaining foot usually becomes flat

Pathology—The most important bone diseases are tuberculosis, arthritis, osteomyelitis, syphilis, and tumors

The pathologist is handicapped in the study of bone because the diagnosis of a lesion depends mainly on the cellular elements and these are the structures most altered by decalcifying agents

Congenital, traumatic, infectious, and neoplastic lesions cause varied pathological changes in the bones and joints, capsules, ligaments, muscles, tendons, fasciæ, sesamoids, arteries, veins, nerves, lymphatic vessels, and lymph nodes

Symptomatology—**History Taking**—History taking is largely concerned with past and present symptoms The various parts of the history are (1) the complaint, (2) the duration, (3) the onset, (4) the cause of trouble, (5) the progress, (6) the treatment previously given, and (7) the general health of the patient The record with regard to the general health should include information concerning the teeth, throat, gastro-intestinal and genito-urinary tracts, diet, weight, height, infections, diseases of childhood and adolescence, and injuries

In all accident cases the physician should inquire regarding minute details so that he will understand the mechanism of the accident as though he had been at the patient's side when the accident occurred

My routine office practice in taking the history of patients with foot and ankle disturbances is as follows:

1. Inquire regarding the complaint—whether it is pain, burning, tenderness, swelling, weakness, deformity, or disability.

2. Attempt to determine where the trouble is located—whether it is in the region of the heel, the longitudinal arch, the transverse or metatarsal arch, or the toes, on the inner or outer border of the foot, on the plantar or the dorsal surface, or in the ankle joint proper.

3. Ask how long the condition has been present and whether it is a new one or the continuation or recurrence of an old one.

4. Ask the patient what he thinks is the possible or probable cause of the trouble.

5. Inquire whether the condition is improving, stationary, or getting worse.

6. Attempt to determine what has been done for the patient by any doctor or other person, what the patient has done for himself, and what result followed each procedure.

7. Ask the patient about the state of his general health. Then inquire about the teeth and throat, recording the answer to the following questions: How many teeth have been extracted? Was the extraction done because of infection, crumbling or decay? How many dead teeth remain in the mouth? When were they checked over by a dentist? What did the last roentgenograms and dental examination reveal? What is the condition of the throat? Are the tonsils in or out? How many attacks of sore throat have occurred? Next, I ask the following questions: Have you now or have you had any sinus trouble? Have you now or have you had any upper or lower respiratory tract troubles? Do you have any trouble with your thyroid gland; either overactivity or underactivity? How is your gastro-intestinal tract functioning? Are you constipated or do you have diarrhea? If you have either is it chronic or intermittent? Have you any trouble with the genito-urinary tract? Do you know of any indications that your bladder or kidneys are not functioning properly? Ask the men "Have you any prostate trouble? If so, what is it, and is it under treatment and by whom? When did you have your prostate examined last?" Ask the women "When did you have a pelvic examination last, and what was the gynecologist's report? How many children have you had and what has been your experience with your feet and ankles before, during and after pregnancy?" Ask both men and women "What is your weight? Is it stationary or fluctuating? What is the most you have ever weighed in your life, and what was your weight at the age of twenty-one? Are you gaining or losing? What is your height?"

Are you fond of meat? Are you fond of eggs? Are you fond of

fish? Are you fond of starches? Are you fond of sweets? Are you fond of salty foods? Are you fond of sweet drinks? Are you fond of pastry? Are you fond of candy? Are you fond of ice cream? When an affirmative answer is given, "Do you satisfy your appetite for these foods and drinks?" Then ask, Are you allergic to any foods or physical agents? Did you ever have gout? Do you come from a rheumatic family? What serious illnesses have you had? Have you ever had heart or kidney disease?

What minor or serious injuries have you had? What was the effect of treatment? Did you get entirely well? Is your trouble intermittent or continuous? Do you have more trouble when you are walking or standing still? Do you suffer from pain and stiffness upon resuming activity after a period of rest? Is your trouble better or worse after rest? Do you have trouble getting "into action" in the morning? Does your trouble come on after fatigue? What makes your pain and disability worse? By what is it alleviated?

Past History —In cases of bony deformity in children, an inquiry should be made especially regarding a history of rickets and syphilis, and in all chronic joint conditions, regarding tonsillitis, dental infection, sinusitis, constipation, gonorrhea, syphilis, tuberculosis, and rheumatism

When babies and young children are examined, the inquiries should be "Was the child born at full term? Was he delivered normally? What was his weight at birth? Was he breast-fed or bottle-fed? At what age did he begin to cut teeth, sit up, walk, and talk?"

In cases of inequality in the length of the legs the possibility of poliomyelitis or a leg or hip injury should be considered

The family history is obtained routinely Inquiries should be made regarding congenital defects and hemophilia

Symptoms —The orthopedic patient is usually concerned with one or more of the following four complaints defects, discomfort, deformity, and disability Symptoms of impending trouble are fatigue, swelling, stiffness and pain

One should distinguish between pain produced by pressure, stretching, movement, leverage, and reflex activity One should inquire whether the pain is relieved by rest Etiologically, the important factors are neurogenic, myogenic, circulatory, and functional Functional factors include malingering, exaggeration and hysteria Skeletal pain includes osseous, periosteal, and synovial discomfort Bone pain is worse at night Children with flat-feet frequently complain of pain in the calf muscles during the night

Tenderness to pressure is usually due to infection, a hematoma, or tearing, as in injury produced by a sprain or strain or to a rupture, fracture or dislocation Sensitiveness to movement is usually due to

My routine office practice in taking the history of patients with foot and ankle disturbances is as follows:

1. Inquire regarding the complaint—whether it is pain, burning, tenderness, swelling, weakness, deformity, or disability.

2. Attempt to determine where the trouble is located—whether it is in the region of the heel, the longitudinal arch, the transverse or metatarsal arch, or the toes, on the inner or outer border of the foot, on the plantar or the dorsal surface, or in the ankle joint proper.

3. Ask how long the condition has been present and whether it is a new one or the continuation or recurrence of an old one.

4. Ask the patient what he thinks is the possible or probable cause of the trouble.

5. Inquire whether the condition is improving, stationary, or getting worse.

6. Attempt to determine what has been done for the patient by any doctor or other person, what the patient has done for himself, and what result followed each procedure.

7. Ask the patient about the state of his general health. Then inquire about the teeth and throat, recording the answer to the following questions: How many teeth have been extracted? Was the extraction done because of infection, crumbling or decay? How many dead teeth remain in the mouth? When were they checked over by a dentist? What did the last roentgenograms and dental examination reveal? What is the condition of the throat? Are the tonsils in or out? How many attacks of sore throat have occurred? Next, I ask the following questions: Have you now or have you had any sinus trouble? Have you now or have you had any upper or lower respiratory tract troubles? Do you have any trouble with your thyroid gland; either overactivity or underactivity? How is your gastro-intestinal tract functioning? Are you constipated or do you have diarrhea? If you have either is it chronic or intermittent? Have you any trouble with the genito-urinary tract? Do you know of any indications that your bladder or kidneys are not functioning properly? Ask the men "Have you any prostate trouble? If so, what is it, and is it under treatment and by whom? When did you have your prostate examined last?" Ask the women "When did you have a pelvic examination last, and what was the gynecologist's report? How many children have you had and what has been your experience with your feet and ankles before, during and after pregnancy?" Ask both men and women "What is your weight? Is it stationary or fluctuating? What is the most you have ever weighed in your life, and what was your weight at the age of twenty-one? Are you gaining or losing? What is your height?"

Are you fond of meat? Are you fond of eggs? Are you fond of

fish? Are you fond of starches? Are you fond of sweets? Are you fond of salty foods? Are you fond of sweet drinks? Are you fond of pastry? Are you fond of candy? Are you fond of ice cream? When an affirmative answer is given, "Do you satisfy your appetite for these foods and drinks?" Then ask, Are you allergic to any foods or physical agents? Did you ever have gout? Do you come from a rheumatic family? What serious illnesses have you had? Have you ever had heart or kidney disease?

What minor or serious injuries have you had? What was the effect of treatment? Did you get entirely well? Is your trouble intermittent or continuous? Do you have more trouble when you are walking or standing still? Do you suffer from pain and stiffness upon resuming activity after a period of rest? Is your trouble better or worse after rest? Do you have trouble getting "into action" in the morning? Does your trouble come on after fatigue? What makes your pain and disability worse? By what is it alleviated?

Past History—In cases of bony deformity in children, an inquiry should be made especially regarding a history of rickets and syphilis, and in all chronic joint conditions, regarding tonsillitis, dental infection sinusitis, constipation, gonorrhea, syphilis, tuberculosis, and rheumatism

When babies and young children are examined, the inquiries should be "Was the child born at full term? Was he delivered normally? What was his weight at birth? Was he breast-fed or bottle-fed? At what age did he begin to cut teeth, sit up, walk, and talk?"

In cases of inequality in the length of the legs the possibility of poliomyelitis or a leg or hip injury should be considered

The family history is obtained routinely Inquiries should be made regarding congenital defects and hemophilia

Symptoms—The orthopædic patient is usually concerned with one or more of the following four complaints: defects, discomfort, deformity, and disability Symptoms of impending trouble are fatigue, swelling, stiffness and pain

One should distinguish between pain produced by pressure, stretching, movement, leverage, and reflex activity One should inquire whether the pain is relieved by rest Etiologically, the important factors are neurogenic, myogenic, circulatory, and functional Functional factors include malingering, exaggeration and hysteria Skeletal pain includes osseous, periosteal and synovial discomfort Bone pain is worse at night Children with flat-feet frequently complain of pain in the calf muscles during the night

Tenderness to pressure is usually due to infection, a hematoma, or tearing, as in injury produced by a sprain or strain, or to a rupture, fracture or dislocation Sensitiveness to movement is usually due to

irritation of a synovial membrane, as in synovitis or trauma with rupture, strain, sprain, fracture or dislocation. Swelling is due to an exudate, hemorrhage, edema, fracture, dislocation, or tumor.

Limitation of movement may be caused by pain, swelling, changes within the joint, or weakness or paralysis of the muscles surrounding a joint.

Fatigue may be due to the end-products of metabolism accumulating in a muscle, overactivity of a normal muscle, or moderate activity of an abnormal muscle. It is a prominent symptom in arthritis. Fatigue is a warning, and pain, a signal of danger.

Symptoms may be deceptive. The physician must analyze such symptoms as pain, fatigue, tenderness to pressure, sensitiveness to movement, swelling, limitation of motion, weakness and limp. He must know the significance of each; in what condition it is found; whether it is usually early or late in appearance; and the changes in severity which it undergoes during the course of the disease.

The chief symptoms of foot conditions are pain, limitation of motion, fatigue, deformity, areas of tenderness and limp. A common symptom is stiffness and pain when activities are resumed after a period of rest. To this condition I have applied the term "post-inertial dyskinesia."

In making examinations of feet, it is important to determine the efficiency of the foot from the standpoint of its bony structure, its muscle power, and its ligamentous and tendinous support.

A normal foot can be rendered inadequate by a painful, tender, or bruised area which compels the patient unconsciously to change his balance and position.

Disability may be due to pain, muscle spasm, bony block, soft tissue block, weak or paralyzed muscles, or deformity.

Pain may be acutely localized as in osteomyelitis. Fever suggests acute infection, osteomyelitis, or poliomyelitis. Tenderness and sensitiveness are found in various lesions.

Limp may be due to such widely different causes as tuberculosis of the hip or a soft corn between the fourth and fifth toes.

In certain conditions there are definite signs and symptoms which are more evident than others: for example, muscle spasm in tuberculosis; acute, sharply localized pain and tenderness near a joint in osteomyelitis, scurvy, and fractures; painless crepitus in Charcot's lesion; severe deformity without pain in a Charcot joint; paralysis in anterior poliomyelitis and Pott's paraplegia; fever and leukocytosis in osteomyelitis.

PHYSICAL EXAMINATION

A hurried physical examination may be misleading. The important physical findings are swelling, redness, tenderness to touch, sensitive-

ness to movement, atrophy, limitation of movement, muscle spasm, muscle weakness, and deformity. Every doctor who treats feet and ankles should have an articulated skeleton of the foot and ankle for handy reference.

In determining lesions of the foot and ankle, or establishing the diagnosis of diseases such as osteomyelitis, poliomyelitis, and arthritis, and recognizing fractures and dislocations, special signs and tests are of great importance. The examination should be performed gently and cautiously, especially in the cases of children. In cases of spastic paralysis an intelligence test should be made.

In every examination it is necessary to consider pain, mechanical block, muscle weakness, paralysis, and psychic elements. Repeated observations during different stages of the disease are often required. The corresponding parts of both feet and ankles should be compared. It is desirable to make photographs of all deformities.

Examination of the new-born babe should include a search for disabilities and for defects and deformities such as spina bifida and club-foot.

In arthritic and neoplastic cases, rectal and vaginal examinations may reveal important information.

Examination of the Foot, Ankle and Leg—Gait.—In order to avoid errors, it is imperative that the examiner follow a routine. If the outline on pages 71 to 74 is followed, a correct diagnosis is practically assured and appropriate treatment will be the logical sequence.

There may be color and temperature changes in the skin, the balance of the foot and leg may be disturbed, and Helbing's sign may be present. (See Fig. 93.)

The shift in weight brought about by a short leg causes an inequality in weight-bearing pressure, resulting in abnormal pressure areas in the foot. Additional pressure on the metatarsal arch of the longer leg may give rise to a relaxation of the arch with its concomitant symptoms. Plantar calluses often form under the metatarsal heads.

Some areas are tender on ordinary examination, and others only when put on the stretch. If the plantar fascia is rendered taut by stretching the sole of the foot, it may be tender to pressure from below. The Achilles tendon may be tender only when the knee is extended and the foot dorsiflexed. Obliteration of normal landmarks is an important sign. Special landmarks are the prominence of the ankle, and the Achilles tendon with its lateral depressions. Examination should include the foot, ankle and leg. Inspection may reveal evidence of a disturbance of weight-bearing. The patient should be examined while standing, sitting, and walking. The color of the skin must be noted and the power of the various muscles determined. A

routine neurological examination and the simple tests of the circulation should be made.

In the routine examination, the muscle power, in all directions, is tested. Then the heel is grasped to see if there is any tenderness of the os calcis at the periphery and on its under surface. The former indicates periostitis; the latter, the possibility of a calcaneal spur or bursitis.

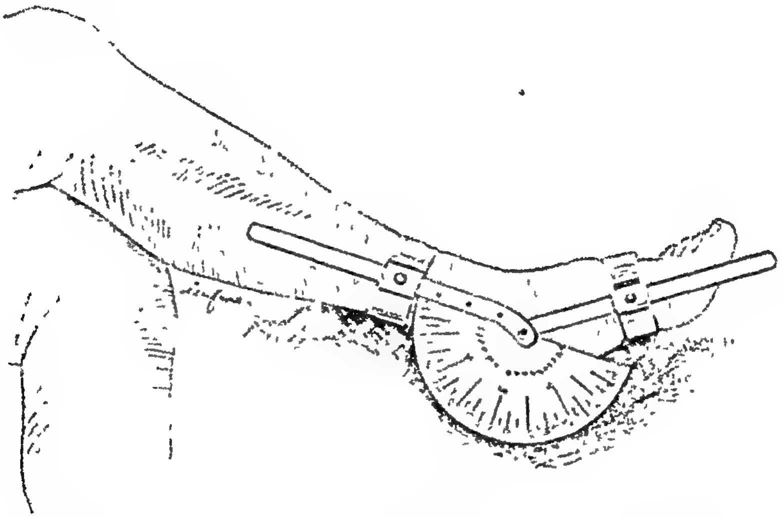


FIG. 18.—Conwell's flexo-extensometer consists of three sets of nickel-plated spring metal clasps with thumb screws and two metal handles and a metal dial, the latter forming one-half circle (180 degrees). (Redrawn from Conwell, courtesy of Surg., Gynec and Obst.)

The next step is an examination for tenderness of the bones composing the longitudinal arch, the os calcis, head of the astragalus, scaphoid, cuneiform I, and the base, shaft, and head of the first metatarsal. The outer border of the foot, and then, in succession, the fifth, fourth, third, second and first metatarsal heads and bases are examined for tenderness. The toes are examined individually. When the normal foot is actively dorsiflexed, the extensor tendons stand out clearly. When edema or infection is present, they do not. The lengths of the toes are noted, and hammer toes, soft corns, calluses or other defects recorded.

The next procedure is examination of the patient standing barefoot on a large paper napkin or towel, facing the examiner. The alignment of the feet and ankles and legs is recorded on a special chart. Visualizing a plumb line dropped from the middle of the patella, the examiner notes whether the plumb is deviated medialward or laterally. (Fig. 92.) He observes whether the patient stands with his feet square or parallel or, as is more common, with his heels together and his toes apart. The color of the skin, the number of toes, any deviation of the big toe, any flattening of the longitudinal arch, any valgus position of the

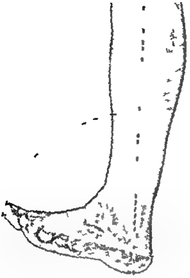


Fig 19 —Voluntary dorsal flexion Normal Dorsiflexion ranges between 10 and 20 degrees

Fig 20 Voluntary plantar flexion Plantar flexion is about 35 degrees

Figs 19 and 20 —In these attitudes the astragalus moves with the foot upon the leg bones as contrasted with adduction and abduction in which the center of motion is below the astragalus (Whitman)

Fig 21 An attitude that simulates the flat foot (See Fig 94)

Fig 22 —Compared with Figure 92 illustrates the voluntary protection of the foot from overstrain (Whitman)

medial malleolus or the ankle, the height of the longitudinal arch, and any undue prominence of the scaphoid.

The second part of the examination is carried out while the patient stands with his back toward the examiner. Observations are made, especially with regard to the heel. It is noted whether the heel flattens out, whether there is prominence of the medial border of the foot, and whether the Achilles tendon comes down straight. A visualized plumb line dropped from the middle of the popliteal space should bisect and be parallel with the Achilles tendon. Deviation of the Achilles tendon medialward, Helbing's sign, indicates that the foot, including the astragalus, is in pronation. (Fig. 93.)

If, when standing, a patient complaining of a foot condition, shows a good longitudinal arch and good balance of the foot, you can say almost positively that the symptoms are due to pes cavus and can predict that you are going to find a high longitudinal with a low transverse arch. If the condition has been present for a considerable time, you will find calluses on the bottoms of the metatarsal heads and deformities of the toes due to contractures of the extensor tendons.

After it has been viewed from in front and behind, the foot is observed from the side.

The next part of the examination is made with the patient sitting on a table at a higher level than the physician. The examiner is seated. The temperature of the skin and any defects such as corns, calluses, bunions, hallux valgus, overriding toes, bunionette, prominence such as "overbone," exostoses at the heel, prominence at the base of the fifth metatarsal, corns, hammer toes, ringworm, soft corns, a tumor mass, birthmarks, melanomas, and discolored areas are noted.

In the next procedure the examiner grasps the patient's heel between his hands and gently compresses it. If this elicits pain, periostitis is present. This may be due to the counter in the shoe or to some toxin generated in the patient's system. Pain elicited by pressure on the spur-bearing area (the inferior-medial quadrant) is due to a spur, a potential spur, osteitis, or bursitis.

The next part of the examination includes pressure along the bones of the longitudinal arch, going from the astragalus to the scaphoid, to the cuneiform I, to the base, shaft, and head of the first metatarsal, and to the phalanges of the first toe. The examiner then starts again at the heel and goes along the outer border of the foot, determining whether there are any tender spots along the os calcis, the cuboid, the base, shaft, and head of the fifth metatarsal, and the phalanges of the little toe.

The examination is then directed to the metatarsal arch from below, the heads of the metatarsals being pressed upon to see if there are any

tender areas or if there is any depression of these structures From there, the dorsum of each toe is examined, then the metatarsal arch itself

The most important tarsal-metatarsal junction is the one described by Morton, that is, the spot about the size of a dime or a quarter which is formed by the cuneiform I, the base of the first metatarsal, the cuneiform II, and the base of the second metatarsal Very often this is the only painful or tender spot in the foot Its significance will be discussed later

To investigate the movements of the foot, the patient is told to dorsiflex, plantarflex, supinate and then to pronate his foot He is instructed to curl his toes down and elevate them After active movements are made, passive motions are used to supplement them, or the feet are moved by the examiner in the manner described, if the patient cannot do so actively The next test is to determine the perception of touch, heat, and cold, and of the position in space of the feet and ankles This is followed by tests to determine whether the Babinski and Achilles reflexes are present One way to test the Achilles reflex is to have the patient kneel on a chair with the soles of his feet directed toward the examiner and then, while the foot is slightly dorsiflexed, strike the Achilles tendon with a percussion hammer

While the doctor is taking the history, he should observe the kind of shoes the patient is wearing He should note also the position in which the patient sits—whether with one leg under the other, with the legs crossed, with the feet in pronation, or with all weight-bearing on the toes, which inverts the transverse arch The significance of the last position is described in the section on metatarsal arch trouble

In every examination of the foot and ankle, the patient should be instructed to stand on one foot and raise the other This is to determine whether he has normal gluteal muscles which are important in foot and back disabilities

The Components of Gait are	
Accuracy	Placement
Firmness	Propulsion
Stability	Poise
Resiliency	Balance
Grace	Synchronism
Timing	Sequence

The most scientific analysis of the human gait was made by Schwartz who employed electrical precision in his determinations

Gait is very important For example, if one walks or runs or dances or engages in athletics with feet splayed out, he cannot supinate or invert, therefore he must perform flat-footedly Ballet dancing is the exception

The standing reflex is very important in polio and other conditions that impose prolonged recumbency. The standing reflex is preserved by a foot-board, massage and maintenance of body temperature in cases accompanied by cold feet due to neurovascular lesions.

Following the examination, the doctor should watch the patient walk around the room in stocking feet and down the corridor in shoes and in stocking feet. Foot balance may be grossly different while standing and walking. In observing several of my patients when they were walking on the street I noted that they were "heel walkers," a fact that was not evident when they walked during the examination in my office.

The next step is the roentgen-ray examination in the antero-posterior and lateral positions to determine whether there are any bone defects or pathological changes. Hoke insists upon a lateral view taken while the patient is standing. One of the important things that a routine roentgen-ray examination will disclose is the relationship of the size of the first and second metatarsal bones, the importance of which was emphasized by Morton.

An examining box with a glass top within may be used. An inclosed mirror is set at an angle so that when the patient stands on the glass and the examiner stands in front of the box, the imprint of the foot is reflected from the mirror to the examiner's eye. Freiberg paints ferric chloride on the foot and tannic acid on the recording paper. When the two chemicals meet, Prussian blue is formed and a good record is obtained. King applied Flak Finger Print ink to the foot and then instructed the patient to stand on a piece of wrapping paper placed on a platform. By this method the details of the sole of the foot and toes in the weight-bearing position are revealed. Prints made at intervals of about six months will show the growth and development of the child's foot, changes in gait and position, and the results of corrective exercises in cases of weak or pronated feet.

Direct inspection of the weight-bearing foot from the front, back, and sides, affords much information. Numerous types of apparatus have been designed to determine weight-bearing areas and record them accurately. One was devised by Steindler. Morton uses the staticometer.

The Examination of Children's Feet.—Examination of children's feet by physicians and pediatricians is an important prophylactic measure. Parents never forgive the doctor who failed to discover a defect, causing much inconvenience and expense later in life, which could have been prevented by simple measures.

Neglect of children's feet is a serious problem because minor changes, minor bits of advice, and minor measures may result in striking improvement. The expression "Mighty oaks from little acorns grow" is applicable to children's feet. Many children are born with moderate

degrees of pronation, valgus, pigeon toes, club-foot, and calcaneus deformities, which could be corrected very simply by means of massage, adhesive strapping, a starch bandage or plaster of Paris, and proper shoeing. Children's feet should be examined immediately after birth. If they present any abnormalities, the examination should be repeated at frequent intervals. Infants who are "belly sleepers" are prone to develop foot imbalance.

If feet are normal, they should be reexamined after six months, one year, and three years. They should be examined as soon as the child begins to walk and about three weeks later to determine whether there are any deviations that require treatment. School children should be examined by competent physicians at regular intervals.

Figure 23 illustrates an improper sitting posture frequently assumed by many children. This causes much strain on the ligaments of the knee joint and causes knock-knees, bow-legs and pigeon-toes or flat-feet.

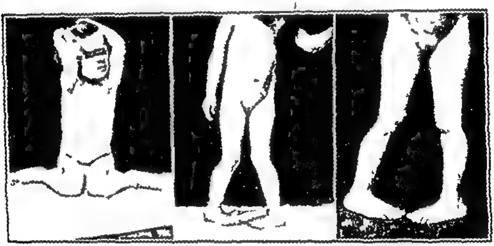


FIG. 23.—Bad sitting and standing foot and leg posture with rotatory defects of legs.

Record Sheet of Routine Examination of the Foot and Ankle[1]

Anatomical location of affected area as referred to by the patient.

STANDING

Inspection. Front view.

TYPE OF FOOT

Flat	Cavus
Alignment	Ankle valgus
Cleanliness of skin	
Inversion	Eversion
Adduction	Abduction
Supination	Pronation
Varus	Valgus

[1] Amplified. From Lewin, Illinois Medical Journal, January, 192–.

Type of Foot—(*Continued*)

Equinus	Calcaneus
Bunion	Hallux valgus
Metatarsus varus	Cavus
Thigh rotation	Leg rotation
Knock-knees	Bow-legs

Abnormal prominence of soft tissues
Extensor tendons of toes
Abnormal prominence of bones
Discolorations
Varicose veins of legs
Ability to supinate feet while standing

Back View

Helbing sign, incurving of tendo Achillis
Abnormal prominences of bone or soft tissues
Ankle valgus
Varicose veins of legs

Side View

Alignment
Cavus — Metatarsal arch

SITTING

Inspection	Color of skin	Nails
	Skin infection (ringworm)	Fissures

Range of Movements

	Active	Passive	Pain
Plantar flexion			
Dorsiflexion			
Inversion			
Eversion			

Muscle spasm (peroneals, etc.)
Muscle paralysis
Corns (hard or soft) — Calluses — Warts — Bursitis
Deformed toes
Other defects
Lewin triangle[5]

[5] A normal depression bounded by the anterior tibial tendon, the retin[illegible] internal malleolus when the foot is adducted and dorsiflexed.

PALPATION

Perspiration | Abnormal skin temperature
Pulsation—Dorsalis pedis, Posterior tibial | Tightness of plantar fascia
Sensitive and tender areas
os calcis lateral borders plantar surface
inner border of foot | outer border of foot
sustentaculum tali | os calcis
scaphoid | cuboid
cuneiform 1 | metatarsal 5
metatarsal 1
heads of metatarsals
taut plantar fascia sensitiveness
contraction of extensor tendons of toes
crepitus

BASIC NEUROLOGICAL EXAMINATION

Motor power
Power to rise on toes and walk
Power to rise on heels and walk
Curling toes down with foot at right angle
Motion in subtalar joint
Dorsiflexors | Plantar flexors
Tibials { prominence, strength
Peroneals { prominence, strength
Skin tests—sensation | Reflexes

WALKING

Natural or unnatural? | aid necessary?
Toe walking | Heel walking[1]

SHOES

Examination of shoes patient is wearing
outside — size — shape
contact areas — worn areas
inside — tacks — nails
lining — wrinkles — rough areas
creases — normal — abnormal
Length Site of impression of big toe joint[2]
Space to end of big toe
Width Points where shoes are worn down { heel, sole
Use of shoe trees

[1] In cases of shortened heel tendon the patient cannot walk on his heels
[2] The middle of the big toe joint should be opposite the point where the shank goes over into the toe

TYPE OF FOOT—(*Continued*)

Equinus	Calcaneus
Bunion	Hallux valgus
Metatarsus varus	Cavus
Thigh rotation	Leg rotation
Knock-knees	Bow-legs

Abnormal prominence of soft tissues
Extensor tendons of toes
Abnormal prominence of bones
Discolorations
Varicose veins of legs
Ability to supinate feet while standing

BACK VIEW

Helbing sign, incurving of tendo Achillis
Abnormal prominences of bone or soft tissues
Ankle valgus
Varicose veins of legs

SIDE VIEW

Alignment
Cavus — Metatarsal arch

SITTING

Inspection	Color of skin	Nails
	Skin infection (ringworm)	Fissures

RANGE OF MOVEMENTS

	Active	Passive	Pain
Plantar flexion			
Dorsiflexion			
Inversion			
Eversion			

Muscle spasm (peroneals, etc.)
Muscle paralysis
Corns (hard or soft) Calluses Warts Bursitis
Deformed toes
Other defects
Lewin triangle[1]

[1] A normal depression bounded by the anterior tibial tendon, the astragalus, and internal malleolus when the foot is adducted and dorsiflexed

PALPATION

Perspiration — Abnormal skin temperature
Pulsation-Dorsalis pedis, Posterior tibial — Tightness of plantar fascia
Sensitive and tender areas
os calcis lateral borders, plantar surface
inner border of foot — outer border of foot
sustentaculum tali — os calcis
scaphoid — cuboid
cuneiform 1 — metatarsal 5
metatarsal 1
heads of metatarsals
taut plantar fascia sensitiveness
contraction of extensor tendons of toes
crepitus

BASIC NEUROLOGICAL EXAMINATION

Motor power
Power to rise on toes and walk
Power to rise on heels and walk
Curling toes down with foot at right angle
Motion in subtalar joint
Dorsiflexors — Plantar flexors
Tibials { prominence, strength
Peroneals { prominence, strength
Skin tests—sensation — Reflexes

WALKING

Natural or unnatural? — and necessary?
Toe walking — Heel walking[1]

SHOES

Examination of shoes patient is wearing
outside — size — shape
contact areas — worn areas
inside — tacks — nails
lining — wrinkles — rough areas
creases — normal — abnormal
Length — Site of impression of big toe joint[2]
Space to end of big toe
Width — Points where shoes are worn down { heel, sole
Use of shoe trees

[1] In cases of shortened heel tendon the patient cannot walk on his heels

[2] The middle of the big toe joint should be opposite the point where the shank goes over into the toe

HOSIERY

Inspection of hosiery

size	holes	
patches	rough spots	seams, knots

ROENTGENOGRAMS

Antero-posterior
Lateral
Stereoscopic
Special positions to demonstrate heels, sesamoids, etc

ROENTGENOGRAPHY OF THE FOOT AND ANKLE

Roentgenography of the foot and ankle is the greatest aid from the standpoints of diagnosis, prognosis, and progress of disease or injury, and the treatment of certain cases. Its importance is especially striking in arthritis, tuberculosis, syphilis, osteomyelitis, fractures, dislocations, and tumors.

In the interpretation of the roentgenogram one must know what to look for, recognize it when he sees it, and be able to interpret it for diagnostic and therapeutic purposes. The normal structure and anatomical relationship must be known in order to determine variations therefrom.

Roentgenography of the foot and ankle must be done with an accurate technic from the standpoint of the positions in which the foot or ankle or portions thereof are placed.

The roentgenogram is important in determining congenital, traumatic, infectious, nutritional, and neoplastic lesions.

The chief points for examination are the heels, toes, spurs, and accessory scaphoid. Each of these has an optimum position for visualization.

An antero-posterior and lateral film should be made whenever possible. A lateral projection of the weight-bearing foot is desirable. In many cases, especially those of children, it is necessary to make similar films of the opposite extremity. Sometimes repeated films must be made at various angles. When the flat film is not conclusive, stereoscopic films may be helpful. Errors in the interpretation of roentgenograms are due to many factors, chief of which are variations in posture and technic.

Roentgenographic Findings.—Baetjer described a normal triangular dark roentgen shadow bounded by the posterior surface of the tibia, the anterior border of the Achilles tendon, and the postero-superior surface of the os calcis. In cases of injury with hemorrhage or exudation this shadow is obliterated.

Sudeck's atrophy is common in the bones of the foot and ankle following injuries.

Unusual width of joint spaces indicates relaxation or stretching of capsules and ligaments.

Abnormal calcification is found chiefly in the Achilles tendon.

Arteriosclerosis is commonly found in adults, especially in the posterior tibial, dorsalis pedis and internal plantar arteries.

According to Morton, the most important evidence to be obtained from the roentgen-ray examination pertains to the distribution of weight upon the five metatarsal segments. The first feature that should claim attention in the roentgen-ray picture is the size of the second metatarsal bone in comparison to that of the three outer metatarsals. The width of the shaft and the thickness of its cortex are indices of the presence or absence of a mechanical disturbance.

Negative roentgenograms may be very misleading in osteomyelitis, tuberculosis, and arthritis. Roentgenograms made early may be negative. Later films will reveal pathological changes.

The physician should not make a diagnosis of bone lesion merely because the roentgen appearance is similar to one he has seen before.

In fracture or dislocation the roentgenogram keeps pace with the injury, but in infections it is usually behind the clinical manifestations. It should be used merely as corroboratory evidence. Calcification or ossification may be a defense reaction to strain, injury, or infection. When the foot and ankle are in a plaster cast, the dosage of exposure should be increased about 25 per cent.

LABORATORY TESTS

Routine examinations of blood and urine should be made in every metabolic case.

Blood Chemistry.—According to Stitt, the normal figures expressed in milligrams per 100 cc. of serum are as follows:

Non protein nitrogen	25 to 35	Cholesterol	140 to 170
Urea nitrogen	12 to 15	Chloride	450 to 500
Uric acid	2 to 3	Plasma CO_2 comb. power	53 to 77
Creatinin	1 to 2	Calcium	9 to 11
Sugar	90 to 120	Phosphorus—adult	3.7
		child	5 to 5.5

The normal calcium-phosphorus quotient is 3.5.

The icterus index is 4 to 6.

In adults, the normal blood calcium is 9 to 10.5 mg. per 100 cc. *In children, it is 10.5 to 11.5 mg.* In adults, the normal content of inorganic phosphorus is 1.8 to 4.3 mg. per 100 cc. Tisdall says *it is* 3.5 to 4 mg. In infants it is higher. The units of serum *phosphatase*

per 100 cc. in normal adults and children and in various pathological conditions are as follows:

Normal adults	1.5 to 4
Generalized osteoporosis	5 to 10
Clinical hyperparathyroidism	25
Localized Paget's disease	5 to 20
Normal children	5 to 12
Active rickets	30 to 165

Sedimentation Rate.—The sedimentation test is the measurement of the speed of separation of erythrocytes from plasma in blood to which an anticoagulant has been added. In general, the sedimentation rate is an index of toxemia.

According to Farley, the sedimentation test is of value chiefly as corroborative evidence in: (1) the differentiation of functional from organic disease; (2) determination of the relative activity or non-activity of inflammatory lesions; (3) charting of the course of inflammatory lesions; and (4) the differentiation of benign from malignant tumors under special conditions.

Basal Metabolism.—There are wide variations in the basal metabolic rate due to mental and physical factors. For this reason the rate should be checked several times. It is especially valuable in cases of thyroid disturbances, arthritis, and obesity.

BIOPSY EXAMINATION

Biopsy is the examination of living tissue. Its chief indications are tuberculosis and tumors. Its purpose is to make an accurate diagnosis upon which to base treatment. It answers the question of whether or not a lesion is tuberculous and therefore, whether fusion of a joint is advisable. In showing whether a tumor is benign or malignant, it permits a decision concerning amputation and other measures. In the technic of biopsy, no factor of error is permissible because infection may be disastrous. The joint is opened for inspection and the removal of tissue. The capsule is opened and the synovial membrane, articular cartilage, and bone may be removed. The diagnostic animals are the rabbit, guinea-pig, and monkey.

If guinea-pigs are inoculated subcutaneously or intraperitoneally with material containing small numbers of Mycobacterium tuberculosis, definite evidence of a tuberculous nature will be discernible with the naked eye in tuberculous animals and in almost all of those dying even after three weeks. The gross lesions exhibit a characteristic predilection for the spleen and liver. It is desirable to prepare a direct smear from the splenic lesions and search for acid-fast bacilli. In guinea-pigs dying of tuberculosis befc ... piration of eight weeks, the lesions of the disease are usual ... kable that experienced clinical pathologi ... cognize t ... examination. How-

ever, failure to demonstrate acid-fast bacilli in suggestive tuberculous lesions in guinea-pigs is presumptive evidence that the lesions are not those of tuberculosis. The presence or absence of acid-fast bacilli within the lesions constitutes the most dependable diagnostic criterion.

Biopsy of regional nodes: Ottolenghi found that biopsy examination of regional lymph nodes is of value in diagnosing tuberculosis of bones and joints.

Lymph node cultures: Allison was successful in growing cultures from regional lymph nodes in approximately six out of ten attempts. The cultures must run for several weeks before they can be called negative.

Aspiration.—Aspiration is the drawing off of fluid, secretion, excretion, pus or tissue. The aspiration is performed under strictly aseptic conditions and followed by the application of a collodion dressing to the wound. A compression bandage or dressing may then be applied. Two per cent procain hydrochloride is injected into the skin and deeper tissues. Needles of large gauge are used because the synovial fluid may be thick and particles suspended in the fluid will block needles of small gauge. With a large needle these particles can be drawn into the syringe for histological examination.

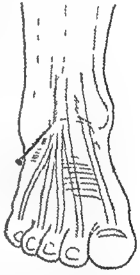


FIG. 24.—Aspiration of ankle joint. Point of entrance of needle into tibio-fibulo-astragalar fossa is lateral to common extensor.

The functions of the secretion are lubrication and protection. Secretion is stimulated by infection.

Examination of Synovial Fluid.—Kling emphasized the importance of aspirating joint fluid in both traumatic and inflammatory conditions. The accumulation of fluid expands the capsule and stretches the ligaments of the joint. The indication for early aspiration of traumatic effusions is based on mechanical and physiological factors.

Blood is absorbed slowly from the joint, and produces inflammatory changes in the synovial membrane. Fibrin is precipitated and may form a nucleus for the development of loose bodies.

Spinal Fluid.—Examination of the spinal fluid is of the greatest value in the diagnosis of poliomyelitis, meningitis, syphilis, and tumors of the spinal cord.

Examination of Other Substances.—The examination of other substances includes examining the contents of abscess cavities (especially in tuberculosis and osteomyelitis), tissue curetted from sinuses, and other tissue by gross and microscopic study.

ORTHOPÆDIC DIAGNOSIS

An orthopædic diagnosis must be made early and must be correct. The diagnostic means at one's command are the history, physical examination, the roentgen study, the tuberculin, Wassermann, and Kahn reactions, and examinations of the blood, spinal fluid, urine, and feces. If there is a sinus, a bacteriological examination should be made of the discharge. In certain cases the joint should be aspirated or explored and the removed fluid and tissue examined cytologically, bacteriologically, and pathologically.

One should take sufficient time to obtain a complete history and to analyze the patient's answers to routine questions.

The roentgenogram should not be used as a substitute for other diagnostic aids.

In unexplainable foot and ankle conditions the possibility of local circulatory and postural disturbances should be considered.

Diagnosis of space occupying lesions of the spinal canal for behavior of foot and ankle, and examination of foot and ankle.

I. Muscle power.

II. Sensory integrity.

Response to sharp and dull. Response to heat and cold.

III. Reflexes.

Achilles. Big toe.

One can cover the entire body, except the foot and ankle, and without knowing the history make a tentative diagnosis, in some cases.

Differential Diagnosis.—In order to make a differential diagnosis, the physician must know the cardinal symptoms of various lesions, deformities, and diseases. He must know especially the characteristic physical and roentgen manifestations of arthritis, tuberculosis, syphilis, gonococcic infection, osteomyelitis, and tumors.

Unlike causes may produce like symptoms, physical manifestations, pathological changes, and roentgen appearances. A limp may be due to a tumor of the brain, tuberculosis of the spine, a boil on the buttock, or a soft corn.

In the differential diagnosis, the most important conditions to be considered are injuries, sprains, fractures and dislocations, tuberculosis, syphilis, osteomyelitis, arthritis, synovitis, tendinitis, bursitis, periostitis, osteochondritis, scaphoiditis, apophysitis of the os calcis, poliomyelitis, spastic paralysis, the muscular dystrophies, neurological lesion, and circulatory disturbances.

The most important questions a physician or surgeon must answer in examining the feet and ankles are:

1. Is the condition a mechanical or postural defect?
2. Is it an infectious condition?
3. If it is an infection, is it local or metastatic?

In other words, the examiner must determine whether the foot complaint is due to something inherent in the foot or comes from some other part of the body, whether it is postural, static, traumatic, infectious, metabolic, or of some other nature

PROGNOSIS

The prognosis in foot and ankle lesions depends upon both local and general factors These include the cause and duration of the symptoms, the treatment, the mental attitude of the patient, the cooperation of the patient, and in the case of the child, the cooperation of the parent

It varies in cases of deformities, disease, and disabilities, and according to whether the etiological factors are congenital, infectious, traumatic, paralytic, neurological, metabolic, circulatory, or neoplastic In a general way the factors determining it are heredity, age, the severity of the condition, the resistance of the patient, the time when treatment is started, the duration of the treatment and the cooperation of the patient, parent or guardian

The time element, *i e*, the interval between recognition and treatment, is important For example, in many diseases early treatment is uniformly successful and late treatment is often unsatisfactory In traumatic cases the prognosis depends upon the severity of the injury, the degree of shock, the amount of hemorrhage, and the presence or absence of infection In paralytic conditions, it depends upon the severity of the paralysis and the treatment

In neurological conditions such as anterior poliomyelitis, spinal cord involvement in fractures of the spine, and peripheral nerve injuries, the reaction of degeneration is an important prognostic test In neoplastic conditions the prognosis depends upon the character of the tumor and the time that elapses before proper treatment is begun

The Mental Attitude of the Patient —The physician must recognize the mental attitudes of the patient which are influenced by his economic and social status Pott's fracture in the wage-earner of the family presents psychological problems differing from those presented by a high school athlete In cases of poliomyelitis, the attitude of the patient toward his disease is very important The esthetic aspect renders the girl especially cooperative, but may also give rise to psychological disturbances The spastic child presents individual psychological problems

It has been pointed out that the present success of the "shady sisters in therapeutics" and the popularity of quackery and charlatanism should impress upon physicians the importance of treating the mind and the emotions of the patient as well as his physical troubles

CHAPTER IV

BASIC PRINCIPLES OF TREATMENT OF FOOT AND ANKLE DISTURBANCES

> "One cannot divide the patient into parts for repair as he can an automobile, but must treat him as a human being, and the treatment given must be the best that the combined knowledge of science can afford."—W. J. MAYO.

THE treatment of foot and ankle conditions includes prophylactic, preventive, and corrective measures. In general, treatment includes the preservation of function and the restoration of function that has not been preserved.

The three outstanding precepts are: Prevent deformity! Minimize disability! Relieve discomfort!

Proper treatment requires a knowledge of the normal mechanics of the joints and the factors underlying disturbances of their mechanism.

Prophylactic treatment has for its aim the prevention of deformity, the preservation of motor and locomotor functions, and the prevention of recurrences after the deformity has been corrected.

NON-OPERATIVE TREATMENT

Non-operative treatment is carried out by means of rest, local applications, protection, immobilization, correction, and physical therapy. This includes rest in bed and the use of splints, braces, plaster-of-Paris casts, vaccines, and medicines. Holman amplified Hilton's principle by stating that physical and physiological rest are necessary when fatigue is the warning, pain the monitor, infection the punishment, and rest the cure.[1]

Treatment varies according to the cause and the stage of the trouble. Relief from pain is afforded by rest in bed and local applications of heat or cold, bed posture, such as is obtained by means of sandbags, pillows, or blankets, splints or casts, injections, physical therapy, roentgenotherapy, and radium therapy. Purposeful movements must be emphasized.

Success in the use of apparatus is bought at the price of constant vigilance. **The price of success is external, internal and eternal vigilance.**

[1] Every physician should read Hilton's classic "Rest and Pain."

Treatment of Disorders of Foot and Ankle
1 Rest
2 Local applications Anodyne Lotion and fomentations
3 Injections
4 Ankle strapping
5 Proper walking—posture
6 Reduction of the length of the step, which often relieves fatigue and pain
7 Proper shoes
8 Shoe modifications—inside—outside—heels—soles
9 Removal of heels or counters or the entire back of the shoe except a strap "Patch pockets" in cases of prominent areas
10 Massage
11 Contrast baths
12 Special exercises
13 Paraffin dips
14 Supports—felt—rubber—metal
15 Elastic anklet
16 Physical medicine
17 Manipulation
18 Braces
19 Splints
20 Casts
21 Medicine
22 Psychotherapy
23 Chemotherapy
24 Surgery

A cushion pad changes the relation of an irritated spot to the irritating object Reduction of weight *per se* often affords much relief and frequently corrects faulty metabolism regardless of how it is accomplished

Rest and Pain —It may be difficult to decide whether a patient needs rest or exercise Many tired and painful feet are relieved by exercises such as golf, walking, tennis, table tennis, badminton, squash, and handball, proving that they need exercise rather than rest

In cases of painful feet, one should caution against starting weight-bearing exercises immediately Two or three days of complete rest are invaluable for patients with painful feet During this rest period, massage and contrast sprays or plunges are very helpful

Frequent elevation of the feet during the day, even though the period may be only a few minutes, aids the circulation

External Applications to Feet —External applications include liniments, lotions, ointments, mud, powders, pads, adhesive, and fomentations

Anodyne Lotion and Its Application With Fomentations.—My modification of Porter's lotion is described in chapters on arthritis.

Physical Therapy.—Physical therapy is one of the orthopædic surgeon's strongest aids in, the relief of pain, improvement of the circulation, the correction of deformity, and the minimizing of disability of the foot and ankle.

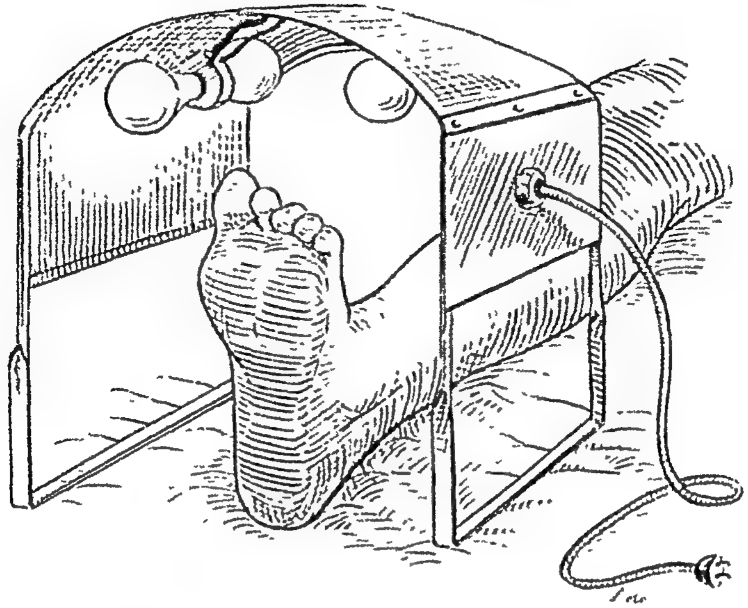


FIG. 25.—Simple electrical "baker." (Footstop omitted for illustrative purposes.)

FIG. 26.—Fotoflood lamp and bracket clamp fitted with a 200 or 250 watt therapeutic heat bulb used as a source of radiant heat. Advantages easily accessible, attachability, low cost. (Redrawn from Krusen, Light Therapy, courtesy of Paul B. Hoeber, Inc.)

The chief physical agents are rest, elevation, heat, massage, exercises, manipulation, bandages, adhesive tape, casts, crutches, canes, walking apparatus, contrast sprays and plunges, the whirlpool bath, hot

paraffin dips, fomentations, the ultra-violet ray, hydrotherapy, diathermy, inductotherm, negative galvanism, electrotherapy, sinusoidal stimulation, pavaex, hyperpyrexia, roentgenotherapy, and radium therapy

The doctor should ask every patient the following questions What is your reaction or your response to your physical therapy? How do you feel before each treatment? How do you feel during each treatment? How do you feel immediately after and the next day after your treatment?

By the use of an improved plethysmograph, DeTakats and Miller have shown that in different grades of arteriosclerosis approximately as much increase of blood flow can be obtained by applying indirect heat as by applying a heat cradle directly to the affected extremity Because direct application of even a moderate amount of heat may lead to increase in pain and acceleration of gangrene, a plea is made never to apply direct heat to any ischemic limb A heat cradle may be safely and effectively applied to the root of the limb and the abdomen proximal to the level of impaired circulation

AMBULATORY TREATMENT

The first part of the ambulatory treatment of a foot and ankle condition is the prescription of a proper shoe If the shoes the patient is wearing are satisfactory, they may be modified by the shoemaker or by the orthopædic surgeon, by the insertion of felt, rubber or cork pads The second part of the treatment consists of exercises for the longitudinal and transverse arches and the heel tendons The third is massage with the use of an anodyne ointment twice a day for a period of five to ten minutes, and the fourth, the use of contrast sprays or plunges The importance of bed treatment either at home or in the hospital for a few days should be emphasized

Modification of the diet may be important in disorders such as arthritis myositis, gout, obesity, flat-feet, metatarsalgia, and calcaneal spurs These diets are discussed in their respective chapters

The purposes of exercise, massage, and contrast sprays should be fully explained to the patient so that intelligent cooperation can be expected

Patients with short heel tendons shorten their strides for comfort, but should lengthen them to correct the condition

Exercises —Special exercises are of the greatest value in increasing the power of the supporting structures and the flexibility of contracted tissues Numerous exercises have been described and recommended Mechanical exercisers are of benefit, but have been exploited There is one apparatus which consists of three sets of rubber rollers This is

placed on the floor, and the patient, either sitting or standing, rolls his feet over the rollers. Another apparatus is similar to a rolling pin.

Exercise is essential in restoring function to muscles, weakened and atrophied as a result of injury and disease. Therapeutically, according to DeLorme, exercises may be classified according to the quality developed in the exercised muscle, namely, power, endurance, speed, and coördination. Failure to discriminate between these classes of exercises leads to the employment of the wrong type of exercise to develop the quality needed in the muscle; inevitably the result is poor. Commonly the attempt is made to restore power by exercises to build endurance; this is a mistake.

Stair-climbing Exercise.—This exercise is not used to develop the quadriceps; it is not used at all, until the patient has built nearly full quadriceps power by the use of previously described quadriceps exercises. Resistance is added to a metal yoke, and the patient goes over and back five times with one weight, rests a minute or so, adds more weight, and then repeats. By use of the yoke, the hands are free to grasp the rail. This exercise was thought necessary because, even though a patient may have good quadriceps power, he may still have some difficulty in stair-climbing, if all the other muscles involved are not proportionately developed. The exercise develops, in the low-repetition, high-resistance manner, all the muscles involved in stair-climbing.

Calf Exercise.—The resistance in this exercise is applied by adding weight to the yoke. The use of the yoke permits the hands to remain free, and the patient can use his hands to steady himself, and maintain balance by grasping a bar in front of him. As strength increases, more weight can be added; and as ankle-joint motion increases, the wooden block can be made higher.

Ankle Exercises.—The apparatus shown in Figs. 27 and 28 was devised to exercise the ankle in both dorsiflexion and plantar flexion, in eversion and inversion. Resistance may be added to the hook at 4 points. The apparatus is also used to help restore ankle-joint motion.

DeLorme Concludes As Follows:

1. Low-repetition, high-resistance exercises produce power.
2. High-repetition, low-resistance exercises produce endurance.
3. Each of these two types of exercises is incapable of producing results obtained by the other.
4. Weakened, atrophied muscles should not be subjected to endurance-building exercises until the muscle power has been restored to normal by power-building exercises.
5. Restoration of muscle power with return of motion in a limb has been neglected in the past. It is, in most instances, preferable to have a limited range of motion with good power, than a normal range of motion with inadequate power.

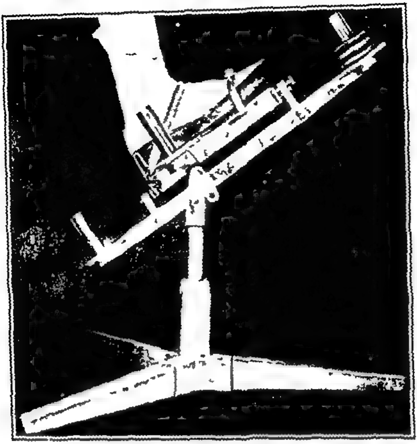


Fig 27

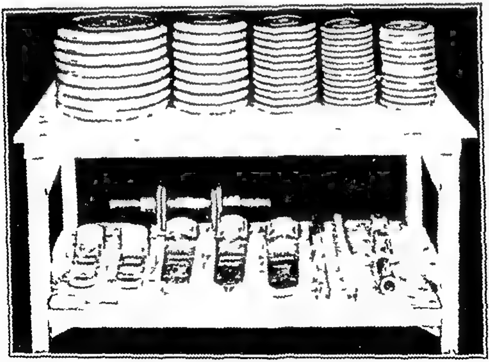


Fig 28

Figs 27 and 28 — Ankle exercise Resistance can be added at 4 points thus giving resistance in dorsiflexion plantar flexion eversion and inversion respectively This apparatus has 180 degrees of motion in all four directions thus also making possible rotary ankle motion (De Lorme Fig 27 courtesy of Jour Bone and Joint Surg Fig 28 Arch Phys Med)

6. Games and group exercises, as practised in reconditioning programs, are unsatisfactory for producing focal muscle development.
7. In order to obtain rapid hypertrophy in weakened atrophied muscle, the muscle should be subjected to strenuous exercise and, at regular intervals, to the point of maximum exertion.

A Stencil Walking Board for Children.—A stencil board is made as follows: A large sheet of wall-board material the size of an ordinary door is painted black and divided lengthwise by a white mid-line.

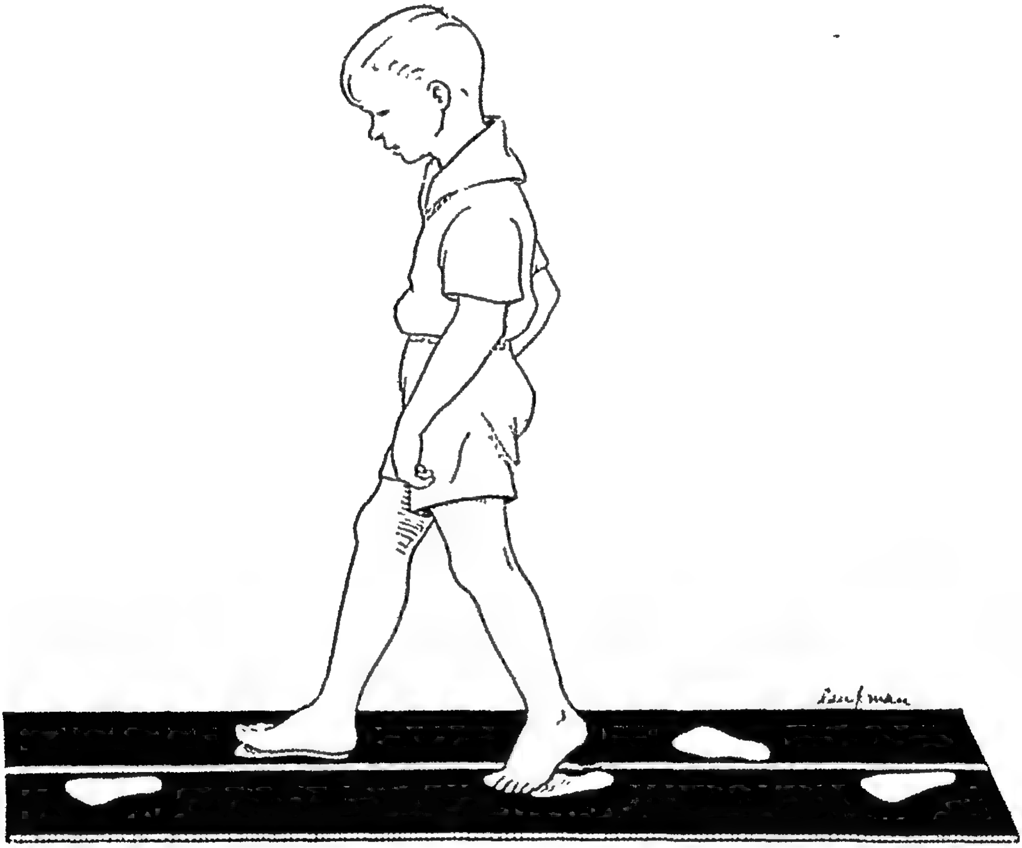


FIG. 29.—Stencil board for foot and leg training. The impression of the bare foot is stenciled in white on a black board. The child is instructed to conform to the outlines.

A stencil the size of the child's foot or shoe is then made of [illegible] ard and the impression painted on the board with white pain[illegible] After the exercise period the board can be placed [illegible] (Fig. 29.)

Ballet Dancing.[1]—There are many misconceptions co[illegible] and Russian ballet dancing and acrobatic and tap da[illegible] relationship to the foot, ankle, and leg. From my ex[illegible]

[1] The reader is referred to an article [illegible] led "Ballet Orthopedic Point of View," which ap[illegible] 923.

has extended over a period of years, in the treatment of dancers, I have come to the conclusion that these activities are highly beneficial I believe that the training, balance, poise, muscular development, and exercise more than compensate for any harmful effects that may occur However, they should not be engaged in too early in life The ballet teacher must have an understanding of anatomy and physiology Ballet shoes and slippers may be fitted with felt pads to support the transverse and longitudinal arches and heels In some cases the toes of the shoes should be padded

Skating —Roller skating is good for any kind of foot, and at first is preferable to ice skating Ice skating is beneficial to the feet, but in

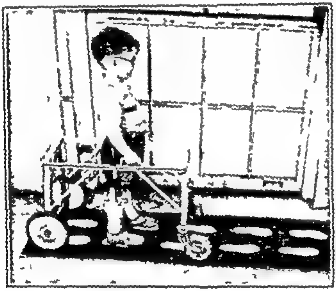


FIG 30 —Walker on stencil board

cases of weak or flat feet, the skate shoe should be fitted with a longitudinal arch pad and the child should wear a 1-inch strap under the skate and around the ankle in a figure-of-eight which will give the longitudinal arch a great deal of support

Massage —Massage improves the circulation and tones up both the rigid and the soft tissues It is a temporary substitute for exercise Many patients should have a few sessions of massage before they begin special exercises

Directions for Massaging the Feet and Ankles —The feet and ankles should be massaged for five minutes every morning and night The maneuver should be done with deep rotatory movements from the toes toward the ankles Imydal unction can be used as a lubricant The calf and Achilles tendon should be massaged Massage may be given by hand, apparatus or electrical machine

6. Games and group exercises, as practised in reconditioning programs, are unsatisfactory for producing focal muscle development.
7. In order to obtain rapid hypertrophy in weakened atrophied muscle, the muscle should be subjected to strenuous exercise and, at regular intervals, to the point of maximum exertion.

A Stencil Walking Board for Children.—A stencil board is made as follows: A large sheet of wall-board material the size of an ordinary door is painted black and divided lengthwise by a white mid-line.

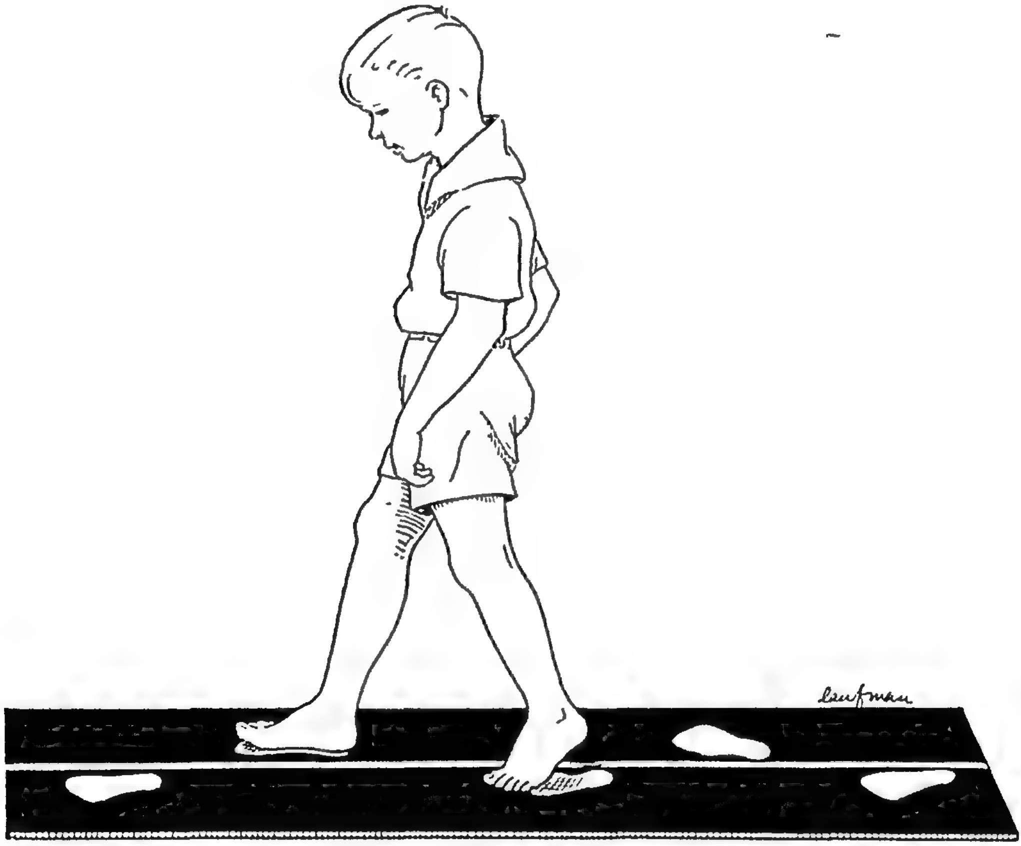


FIG. 29.—Stencil board for foot and leg training The impression of the bare foot is stenciled in white on a black board The child is instructed to conform to the outlines.

A stencil the size of the child's foot or shoe is then made of cardboard and the impression painted on the board with white paint and a brush. After the exercise period the board can be placed behind a door. (Fig. 29.)

Ballet Dancing.[1]—There are many misconceptions concerning Grecian and Russian ballet dancing and acrobatic and tap dancing and their relationship to the foot, ankle, and leg. From my experience, which

[1] The reader is referred to an article by the author entitled "Ballet Dancing from the Orthopædic Point of View," which appeared in Hygeia in 1923.

has extended over a period of years, in the treatment of dancers, I have come to the conclusion that these activities are highly beneficial I believe that the training, balance, poise, muscular development, and exercise more than compensate for any harmful effects that may occur However, they should not be engaged in too early in life The ballet teacher must have an understanding of anatomy and physiology Ballet shoes and slippers may be fitted with felt pads to support the transverse and longitudinal arches and heels In some cases the toes of the shoes should be padded

Skating —Roller skating is good for any kind of foot, and at first is preferable to ice skating Ice skating is beneficial to the feet, but in

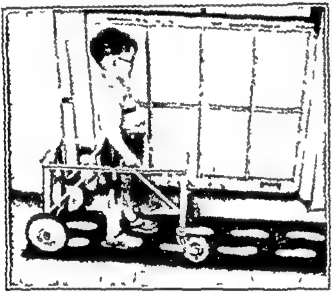


Fig 30 —Walker on stencil board

cases of weak or flat feet, the skate shoe should be fitted with a longitudinal arch pad and the child should wear a 1-inch strap under the skate and around the ankle in a figure-of-eight which will give the longitudinal arch a great deal of support

Massage —Massage improves the circulation and tones up both the rigid and the soft tissues It is a temporary substitute for exercise Many patients should have a few sessions of massage before they begin special exercises

Directions for Massaging the Feet and Ankles —The feet and ankles should be massaged for five minutes every morning and night The maneuver should be done with deep rotatory movements from the toes toward the ankles Imydal unction can be used as a lubricant The calf and Achilles tendon should be massaged Massage may be given by hand, apparatus or electrical machine

Contrast Baths and Plunges.—Contrast baths and plunges improve the circulation by alternately dilating and constricting the blood-vessels. They tone up the tissues.

Directions for the Use of Contrast Baths.—*Contrast Sprays.*—Sit on the side of the bathtub with the feet inside the tub and spray both feet with warm water for exactly one minute; then with cool water for

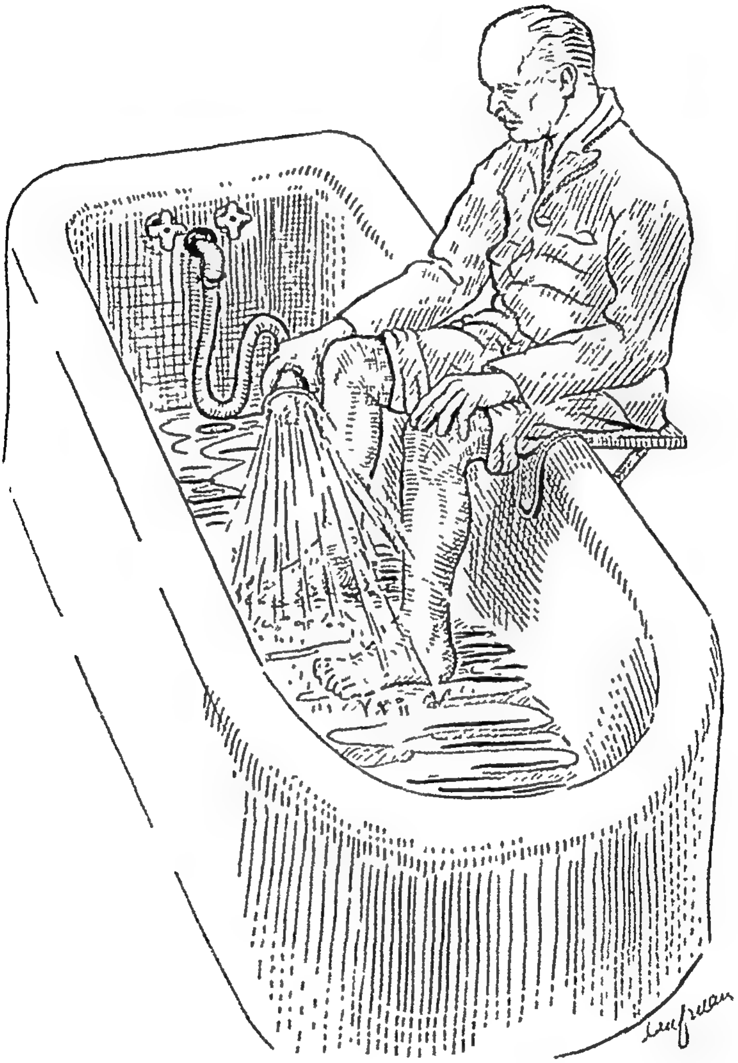


Fig. 31.—Contrast foot and leg sprays.

exactly one minute. Alternate in this manner for ten minutes twice daily. In many cases the period of the cool spray is cut to thirty or fifteen seconds. (Fig. 31.)

Contrast Plunges.—Obtain two buckets, each large enough for both feet. Fill bucket No. 1 about two-thirds full of warm water, and bucket No. 2 two-thirds full of cool water. The buckets may be placed in the bathtub. Sit alongside the buckets and place both feet in the warm water for exactly one minute. Remove the feet and

place them in the cool water for exactly one minute Alternate in this manner for ten minutes, *i e*, five minutes in each bucket, twice daily The original temperature of the water in each bucket must be maintained

The period of immersion in the buckets or of spraying varies according to the indications Beware of a striking contrast in arthritic patients or those who have physical allergy

Contrast plunges are inconvenient and cause a certain degree of shock, especially in women Contrast sprays perform practically the

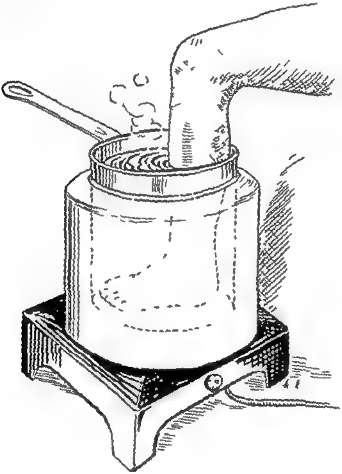


Fig 32 —Apparatus for hot paraffin dips for foot and ankle

same function and are more pleasant to the patient The whirlpool bath is a very effective agent, especially in the after-treatment of injuries

Hot Paraffin Dips for the Foot and Ankle —The technic of the use of paraffin dips is as follows The paraffin is heated to the melting point and allowed to cool After it has cooled to a temperature of about 140°, the foot is plunged into it and withdrawn after about fifteen seconds This is repeated from eight to fifteen times until there is a heavy coat of paraffin on the foot and ankle (See Fig 32)

Directions to the Patient.—Buy a double boiler in household department store.

Buy an electric plate at any shop that carries electrical equipment.

Buy 12 pounds of parawax.

Add 12 ounces of light mineral oil. This can be purchased at any drug store.

The melting point of the wax is approximately 118°.

Before starting the treatment, allow the wax to cool for an hour or until a heavy coating of wax has formed. The cooling may be hastened with an electric fan, but the wax must be stirred frequently.

The mixture of the paraffin and oil may be used repeatedly without changing.

Dip the foot and ankle in and out of the bath so that a thin coating of paraffin adheres to, and congeals on, the skin. Repeat the immersion from ten to twenty times, until the adhering paraffin is of sufficient thickness to allow you to keep the member immersed in the bath with comfort for ten minutes. In the case of a foot condition repeat about ten or fifteen times or until a heavy "shoe" collects on the foot. Then cover the foot and ankle with a small blanket or bath towel for fifteen minutes. At the end of that time peel off the "shoe" and replace it in the bath.

Warnings.—Be sure to heat over water and not directly over a flame. Do not allow the wax to fall on the floor as it is very slippery. Do not move the joints of the member being treated, because cracks in the paraffin permit hot paraffin to trickle in and burn the skin. Do not strike the side of the container or any object therein, because this will cause a break in the paraffin and may be followed by a burn.

Manipulation of the Foot and Ankle.—Manipulative surgery is the correction of deformity and restoration of the function of bones, joints, muscles, tendons, and ligaments by non-operative means. It is one of the oldest forms of therapy. The art of manipulation is possessed by all too few surgeons. Manipulation is a delicate procedure which requires an exact technic because errors are often disastrous.

Elmslie emphasized the fact that manipulative surgery has a special tendency to fall into the hands of the unqualified because the public assumes that the irregular practitioner has some peculiar skill. He has, moreoever, unrestricted power to advertise his successes, and his failures are generally hidden by the gulled victims.

Before manipulation is attempted, it is necessary to rule out tuberculosis, osteomyelitis, sepsis, acute infectious arthritis, and neoplasm.

The art of manipulation requires a fundamental knowledge of the anatomy, physiology, and pathology of joints and their surrounding tissues. (See Figs. 31–37).

The general principles of manipulation include: (1) proper selection

of cases, (2) consideration of possible contraindications, (3) preoperative care, (4) a correct technic, and (5) after-care

One of the prerequisites for manipulation is adequate roentgenographic studies

The effect of manipulation is no mystery to anyone who has seen the interior of abnormal joints and understands the pathology and pathogenesis of the tissue changes

No one should perform a manipulation unless he is in a position to undertake the after-treatment himself or to give specific instructions to a physical therapist

The manipulator must temporarily transpose his brains, eyes, and ears to his fingers and hands

Fig 33 —The right hand of the operator grasps the external malleolus and the left hand forces the foot into valgus

The anesthesia should be intravenous pentothal-sodium supplemented by cyclopropane or ether

The after-care often determines the success of the procedure

The benefit that follows is due in part to the readjustment of the joints but chiefly to the release of adhesions and muscle spasm and stretching of the shortened muscles A tendon does not stretch In some cases it is pulled away from its muscle or bony insertion

Manipulation is indicated in cases with adhesions, cases of functional or hysterical disturbances, fractures, unreduced dislocations or subluxations, and a miscellaneous group of lesions It is indicated principally in conditions which follow several weeks after an injury, that is, lesions due to adhesions rather than arthritis

The causes of the various foot and ankle lesions with residual effects which may be treated by manipulative surgery include congenital, infectious, traumatic, myogenic, neurogenic, circulatory, and postural factors.

Adhesions and Contractures.—An adhesion was defined by Sir Robert Jones as a pathological band restricting the normal movements between two adjacent tissues and caused by a serous or hemorrhagic exudate from the blood-vessels, either inflammatory or traumatic in origin.

Stiffness of the ankle joint is generally due to the presence of adhesions within or around it. Very often the adhesions are both extra-articular and intra-articular.

Neuropathic contractures may be due to *poliomyelitis*, spastic paralysis, or hysteria. The type of pes cavus that develops during adolescence, when there is a contracture of the plantar fascia, is probably of neurological origin.

Adhesions undetectable by clinical examination will often be felt and heard to "give," and the patient will be relieved.

Contraindications.—In the selection of cases for manipulative therapy the joint should be "cold." There must be no active infection.

Manipulation should be avoided in the cases of elderly and feeble patients and those with active rheumatism. Particularly in elderly persons, a considerable degree of shock may be caused by forced movement.

In difficult cases a series of manipulations is preferable to the use of considerable force in one session.

Tearing of tissues necessarily means more fibrosis, more adhesions, and a joint that is more limited in its motion than it was before.

Preparation of Patient.—The general preparation of the patient is the same as for open operation. Anesthesia should include: (1) the hypodermic injection of morphine and atropine one hour before the manipulation; (2) induction with nitrous oxide or ethylene; and (3) complete anesthesia under ether.

Technic of Manipulation.—Proper positions of the patient and surgeon are essential for correct manipulation. On the part of the operator, the sense of touch and a combination of caution and determination in the technic are more important than physical strength. The use of extreme force is never necessary and may do harm. In cases in which adhesions are so dense that extreme force would be necessary, open operation is preferred.

Postmanipulative Care.—This involves bandaging, support, the application of a cast for a few days after the position of the foot and ankle have changed, physical therapy, proper shoeing, and possibly a brace. If possible, physical therapy should be given the same afternoon and

night Narcotics should be avoided and the affected part moved frequently (if no cast is applied)

Eighteen General Precepts on Manipulative Surgery

1 Never manipulate in the presence of tuberculosis, osteomyelitis, acute infections, acute arthritis, sepsis, or neoplasm
2 There must be no signs of active infection, *i e*, the joint must be "cold"
3 Never manipulate without recent roentgenograms
4 Never manipulate an arthritic patient without determining the uric acid content of the blood to rule out a gouty process
5 Complete relaxation usually requires ether anesthesia
6 The fact that the patient is asleep does not give the surgeon the right to hurt him
7 Do not use the foot as though it were a pump handle
8 "Non vis sed arte" Not by force but by skill
9 Beware of injuring the epiphyses, especially in infants and young children
10 "You can always go back for more"
11 Remember the bones are usually atrophic but the ligaments are not, and that bone will break before the ligaments "give"
12 Remember the bone and joint changes are always worse than the roentgenogram indicated
13 If you break a bone you cannot start early motion
14 Breaking an adhesion causes hemorrhage, which is the starting point of another adhesion unless the joint is kept active
15 A stretched adhesion causes pain, a torn adhesion is less painful Therefore, do not stretch adhesions, break them
16 Never immobilize a foot and ankle in the position of maximum correction
17 Never manipulate unless you are prepared to supervise the aftercare
18 The patient should make active movements at the earliest possible moment following the manipulation

The joint should be put through its full range of movement daily The patient should be instructed in a few simple exercises to be performed for a few minutes morning and evening "A movement a day keeps adhesions away" (Coates)

In manipulating the foot and ankle the excursion to be obtained may be visualized as the arc of a circle The first zone, *a* to *b*, is a free zone Zone 2, *b* to *c* is blocked and must be broken down Zone 3, *c* to *d*, is another free zone, and Zone 4, *d* to *e*, another rough or blocked zone

The signs which are indications for manipulation are limitation of movement and malalignment The symptoms are limitation of movement, pain, and disability The pathological changes involved are

chiefly adhesions and contractures. The etiological factors include injuries which may be minor sprains and strains followed by malalignment or severe injuries such as fractures and dislocations. The second etiological factor appears after infections. The third is a postural defect such as flat-foot. The fourth is arthritis.

Manipulation of the foot and ankle with the patient awake requires a considerable period of time. I prefer to anesthetize the patient or the local area and perform the manipulation rapidly. The anesthesia may be induced with gas followed by ether, local anesthesia, nerve block, or the intravenous injection of a drug such as pentothal sodium.

Manipulation of an ankle includes dorsiflexion, plantar flexion, inversion, eversion, supination, pronation, and circumduction. The heel

Fig. 34

Fig. 35

Fig. 34.—Manipulation of the foot and ankle to obtain inversion, supination, and varus. The left hand of the operator grasps the heel; the right hand of the operator forces the foot in corrected position.
Fig. 35.—Manipulation of the metatarsal area.

is held firmly by the operator's left hand and the foot forced into hyperdorsiflexion and from this position into hyperplantar flexion with his right hand. (Fig. 35.) In performing dorsiflexion it is an advantage in most cases first to flex the knee in order to relax the gastrocnemius and soleus. Plantar flexion should be performed with the knee extended. The third maneuver is forcible supination with the heel grasped with the left hand and the outer border of the foot grasped with the right hand. In the fourth maneuver the heel is grasped with the right hand and the foot forcibly pronated or everted with the left hand. The fifth maneuver is mobilization of the subastragalar joint by holding the ankle joint and forcing the foot in various directions.

In mobilizing a subastragalar joint, care must be taken to avoid causing lateral injury to the ankle joint proper. The next manipulation is

in the scaphoid area where adhesions are common, and the next in the metatarsal region where the up-and-down movement is slight and there is very little lateral movement The metatarsal area is manipulated up and down to restore its normal dome shape (Fig 35) The last manipulation involves the toes, which are manipulated dorsalward, plantarward, and laterally The big toe joint is pulled in extension This is accomplished with a gloved hand or by means of lineally applied strips of adhesive tape Manipulation of the big toe joint very often affords considerable relief from adhesions and capsulitis

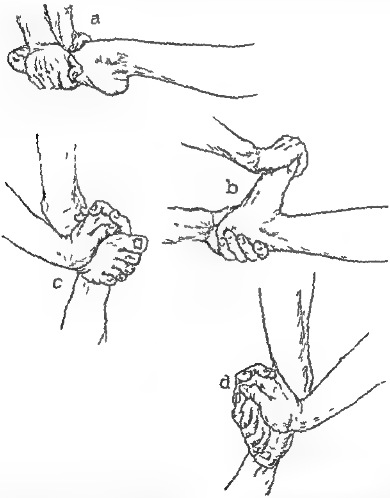


Fig 36 —*Method of wrenching fibrosed feet before correcting weight-bearing following fracture of the os calcis* (Forrester, Imperative Traumatic Surgery courtesy of Paul B Hoeber Inc)

When adhesions exist in the extensor sheaths, firm thumb pressure is exerted upon any spot that is particularly tender and a rapid movement of plantar flexion is performed When the adhesions involve the flexor tendons behind the internal malleolus, similar pressure is exerted but the foot is forcibly dorsiflexed and everted When the adhesions involve the peroneal tendons, the foot is dorsiflexed and simultaneously

inverted. When dorsiflexion is limited by contracture of the tendo Achillis, much can be accomplished by one or more manipulations.

In obstinate cases manipulation must be combined with open or subcutaneous tenotomy of the tendon. The patient lies upon a couch or table with the knee flexed. Grasping the heel with one hand and the front part of the foot with the other, the surgeon forcibly inverts the foot, using as a fulcrum a wedge-shaped block covered with leather upon which the middle of the inner border of the foot rests. In difficult cases of stiffness of the mid-tarsal and ankle joints the Thomas

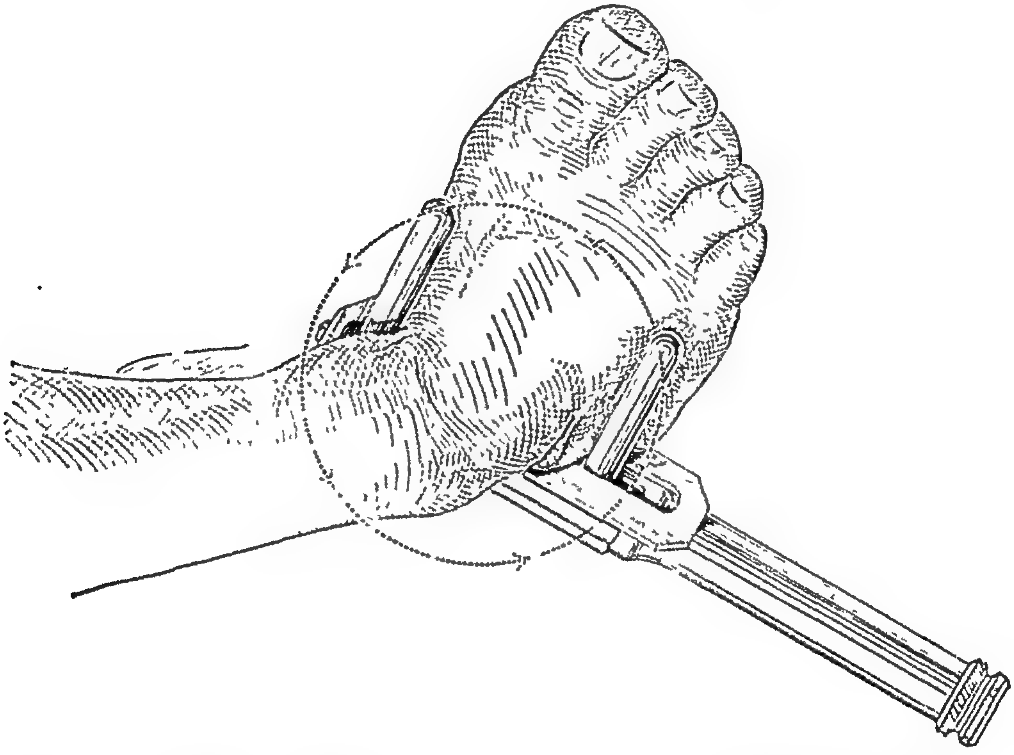


FIG. 37.—Method of applying Thomas wrench to foot, making strong inversion. If the foot cannot be inverted and properly lined up with the tibia, the pain will not be completely relieved. (Magnuson's Fractures, courtesy of J. B. Lippincott Company.)

wrench (Fig. 37) is an aid. This instrument must be used with great care, and the force employed must be steady and continuous but never spasmodic. The manipulation should be followed by fixation of the foot in the corrected position in plaster. Forward slipping of one of the peroneal tendons onto the outer surface of the external malleolus may occur because of rupture of the external annular ligament. This should be immediately treated by plantar flexion and eversion of the foot combined with digital reposition. The tendon must be retained in its proper position by firm pressure. Ellis Jones designed a satisfactory operation for this condition. (Fig. 180.)

Unqualified Practitioners —One of the serious situations created by the unqualified practitioner or the practitioner who is qualified to do certain things but does not know the limits of his qualifications is due to his guarantee to cure in a certain period of time The qualified physician and surgeon learns very early *to promise only an honest effort based upon extensive study and experience*

There is no secret or mystery to the procedures performed by certain high-pressure, highly publicized manipulators of the foot The chief manipulations are the replacement of a moderately subluxated big toe joint, scaphoid, cuboid and cuneiform I, and stretching of the capsules of the metatarso-phalangeal joints

Shoes —A shoe should be made on a straight last and should have a round toe and a heel of moderate height It should be narrow in the heel and through the waist of the foot, but wide through the ball The shank must not be too wide or too narrow The rigidity and flexibility varies with the person and his defects The counters should not cause irritation Little difficulty is experienced in obtaining properly shaped shoes for children and men, but girls and women are the victims of style, vanity, and the shoe salesman *They prefer to fit the eye rather than the foot*

Two important difficulties in fitting shoes are presented by the foot of the growing child and the flexible foot of the woman The flexible adult foot has two sizes one while sitting and one while bearing weight, but the shoe has only one size

The long, narrow foot is difficult to fit, especially in the case of young growing boys and girls The difficulty is due to the comparatively long distance between the tip of the os calcis and the middle of the big toe joint and the narrowness of the foot Small, square feet are also hard to fit As the child walks upon the same substances as the adult, *he should have the same efficient protection for his feet*

For the proper care of both children's and adults' footwear, shoe trees are essential The drying of shoes that have been wet is important Linings of the shoes must be smooth, and there must be no tacks or seams to cause irritation

Constant pressure produces an ulcer, inconstant pressure causes overgrowth of tissue It is a great mistake for workmen to use old shoes for work *During physical labor the foot should have the best possible support*, which cannot be supplied by old, worn-out shoes Work shoes need shoe trees The work shoes in certain occupations are very important *In many hazardous occupations the shoes are required to withstand tremendous forces and pressures*

The function of shoes is to protect against the hardness and unevenness of the ground and against cold, to provide support, and to determine locomotion (*i e*, steer you on a certain course)

Shoes will not correct a gross defect unless the muscles are strong enough to assume the burden.

A note in passing to call attention to the fact that although 40 million pairs of shoes were produced in the U. S. A. in September, 1946, we were 550 million pairs short of our needs.

Rubber soles may be undesirable, because they cause the step to stop short, forcing the foot down into the shoe.

When a child walks as though it is stepping on eggshells one should suspect its shoes are too short. Another indication of short shoes is redness at the base of the big toenail. Shoes can be bought in split sizes and to go over plaster-of-Paris casts and braces.

According to independent investigations cited in the *Journal of the American Medical Association*, there are 189 trade names for shoes with the designation "Dr." as a part of the name. The title "Dr." suggests that the shoes were especially designed by a physician for certain types of foot weakness or malformation, whereas in the vast majority of cases they were probably designed by a shoe manufacturer who then secured the consent of some unwary physician to use his name.

Since feet differ so much from each other, it should be at once apparent that no shoe constructed according to a standardized type can be adequate for all types of painful or weakened or deformed feet. It is to be hoped that the leaders in the boot and shoe manufacturing industry will pay special attention to all types of misleading promotion.

The Height of Women's Heels.—The height of women's heels has been the subject of considerable discussion. Many women are better off with high than with low heels. Strain of the Achilles tendon is transmitted to the hamstring muscles, knee, thigh, hip and back.

High heeled shoes cause an increased lumbar lordosis and a pelvic tilt. In young women this tilt can be compensated for readily. In older women or people with arthritic changes this alteration of position may cause a strain and backache. Women who walk in high heeled shoes with small weight-bearing surfaces may have an altered gait and an altered posture. This altered posture, when associated with fatigue and visceroptosis, may be a factor in vasomotor disturbance.

Ober has recently advised raising the height of men's heels often up to $1\frac{1}{2}$ inches to compensate for short Achilles tendons.

This measure may relieve many persons of fatigue. It may have a beneficial effect on several conditions such as intermittent claudication, nocturnal leg cramps, fatigue of the surgeon or dentist and some knee strains.

It is surprising to observe how frequently Achilles tendons are short if one will take a few seconds necessary to make the simple test.

Comments on Styles in Women's Shoes.—Toeless shoes may help

bunions, hallux valgus, and ingrown toenails by removing the lateral pressure from the end of the big toe

"Heelless" or counterless shoes with a strap may be harmful because they do not furnish stability. The shoe with a proper counter is more stable than the shoe without.

It has been estimated that 8 out of every 10 pairs of shoes are cut with open toes. Wedge-soles and platform heels are very popular, the newest versions being stronger in eye-appeal comfort and ease of application. They come in street, lounging and play shoes in every style, color and material

Low-heeled walking shoes have been perfected into models of extreme smartness. Square cut heel and toe combinations of dull contrasting materials foreshorten even the larger sizes into amazingly small-looking footwear

Time alone will tell what effect these styles will have upon the comfort and health of the feet. There is no doubt that counterless shoes permit drying and cracking of the skin of the heels

The Closetful of "Unwearable" Shoes—Many patients, especially women, tell the orthopædic surgeon that they have a closetful of shoes many of which were made to order at a cost of from $15 to $40, but none of them can be worn. In these cases the orthopædic surgeon can save the patient much money by prescribing a proper shoe with certain modifications within and possibly without

Other Notes Regarding Shoes—There is a little tendency to revert to a shoe with an elastic side instead of laces, the "Congress gaiter" Shoes for roller skating and ice skating should be carefully selected. Bowlers' shoes have too little support. Many of them should be padded with a cushion insole of felt. If a bowler has a depression of the longitudinal or transverse arch, pads should be inserted in the shoe. For football, track, and tennis, it is advisable to wear what is called a "pusher" over the toes. This is made of chamois and acts as a cushion against the shoe. Track shoes should be carefully selected and free from irritating surfaces. Shoe trees are essential for proper shoe sanitation and care. All rough linings should be smoothed out. Hosiery should not be too large or too small, and should be free from irritating surfaces

For the golfer, a shoe with cleats is advisable. The tennis player should wear shoes that include the ankle. For persons with certain types of circulatory troubles there are large fleece-lined, round-toed shoes which are comfortable and warm

The Problem of Footwear—What constitutes the ideal footwear?

One must recognize the fundamentals of foot structure and function. Many of the strains to which feet are subject under civilized conditions are hard floors, cement sidewalks, and asphalt streets. Many women demand shoes that are fashionable

Lake emphasizes that fit is more important than shape in shoes. The correct size is better determined by the feel of the foot when walking in a shoe, than by reference to sizes. Viewing of the foot through a fluoroscope is often a matter of salesmanship; neither sales-

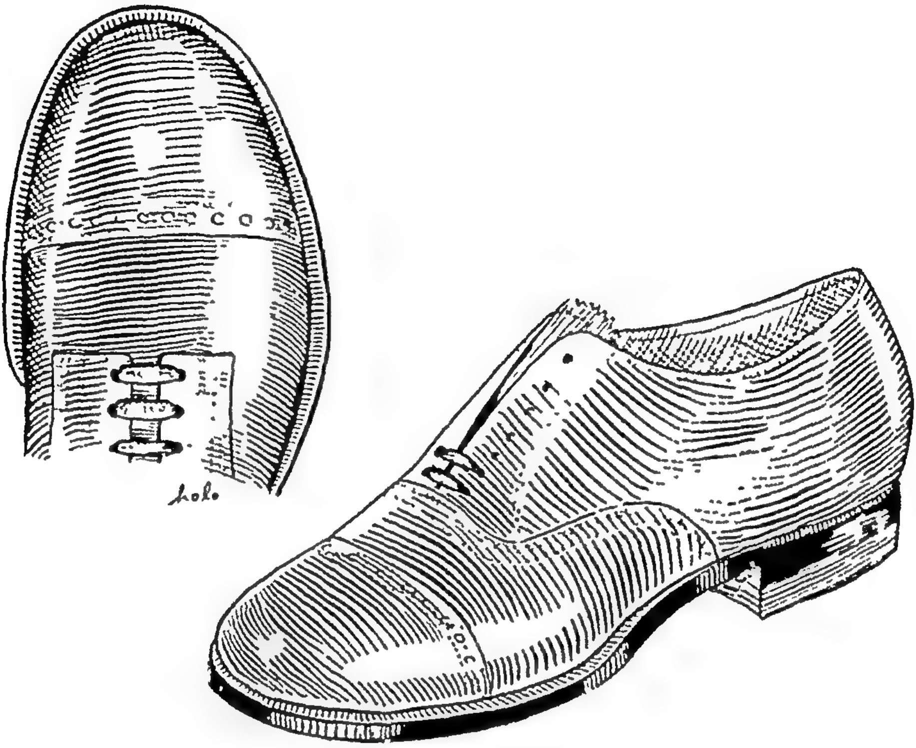


FIG. 38.—A satisfactory type of man's shoe. Note the blucher type on the left.

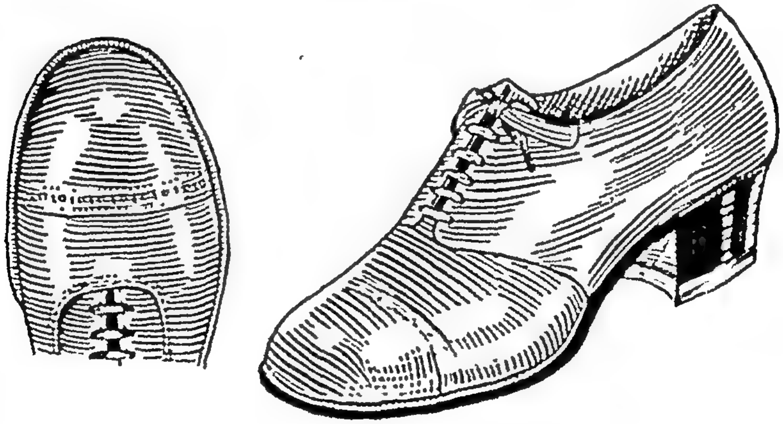


FIG. 39.—A satisfactory type of woman's shoe. Note the blucher type on the right.

man nor customer knows how to interpret what he sees. The size of a foot is determined by its length measured on a scale of $\frac{1}{3}$ inch per size, with the zero at 4 inches. The size of the shoe should be two and one-half sizes larger than the foot to provide for increased length during weight-bearing. The fit at the heel and instep should be snug. The basis of sizing is length.

The shape of the shoe is determined by the last upon which the shoe is made. The inner border of the shoe should be straight, as is the inner border of the normal foot.

A heel ⅞ of an inch high affords a good basis for walking and does not disturb the balance of the foot. A heel up to 1½ inches high produces only a slight derangement readily overcome by natural compensating mechanisms. A heel of more than 1½ inches however, transmits body weight and stresses of locomotion to the metatarsal heads, which are unfitted to sustain such stresses more than momentarily.

The question of rigidity of the sole is controversial. Both rigid and flexible shoes are permissible depending upon their use. For most arduous wear, long marches or climbing, a very stout, rigid boot with a thick, heavy sole is advisable. In the ordinary walking shoe a happy medium between rigidity and flexibility is desirable. A good blocked toecap provides room for toe movements and protects against many injuries.

A steel shank in the sole increases the rigidity at the narrow waist of a shoe and does not interfere with metatarsophalangeal joint movement if the shank ends behind the metatarsal heads.

Bowling and skating shoes that lace down to the toes are often useful.

Shoe Trees.—Shoe trees are important in maintaining shape and smoothness of shoes and their linings. They are especially valuable in pes cavus cases where the person deforms his shoes often to a serious degree. The leather wrinkles, the shoe lining wrinkles, it wears out and causes blisters or abrasions.

There are many occupations especially in damp or wet places that moisten or wet the shoes which predisposes to irregularities and misshapen shoes.

It is far better to maintain or restore the shape of the shoe by means of a shoe tree than by a person's foot.

Some stores formerly maintained a progressive shoe tree service for children.

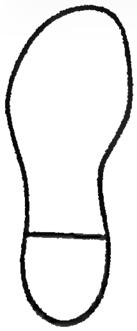
Modifications of Shoes.—The chief modifications of shoes include variations of the heels, soles, counters, and the big toe region. The chief modification of the heel is one which is longer and higher on the inner than the outer border and compels the wearer to walk over the proper walking angle, so that a weight-bearing line dropped from the middle of the patella bisects the tibia and the astragalus.

A reversed Thomas heel is one with the outer border longer and higher than the inner. Its special indications are conditions in which it is desired to transfer the weight from the outer to the inner border,

such as traumatic affections of the outer border of the foot, and in the follow-up care of talipes equinovarus.

PRESCRIPTION BLANK FOR MODIFICATION OF SHOES.

OUTER BORDER INNER BORDER



DATE__________

TO__________

ADDRESS__________

MR.__________

PLEASE FIT A PAIR OF__________

FOR__________

SPECIFICATIONS:__________

MODIFICATIONS:__________

	LENGTH	HEIGHT
INNER BORDER		
OUTER BORDER		

__________M. D.

The chief modification of the sole is elevation of the outer border by means of a wedge, the highest point of which is under the base of the fifth toe.

Modifications of the metatarsal area include a bar, cleat, or crescent made of leather or rubber which is secured to the bottom or between the layers of the sole, at a point just behind the heads of the metatarsal bones.

A device called the "kee foot" is a thick rubber strip which is nailed to the medial border of the shank of a flexible shank shoe so that it does not quite abut against the heel and extends forward to a point back of the head of the second metatarsal bone.

Modifications of the counters include removal of the counter to prevent irritation of the heel and prolongation of the counter on the inner border to protect certain bones and ligaments of the arch.

Removal of the counter of the shoe is often an important means of relieving considerable pressure in conditions affecting the heel. The entire back of the shoe can be cut out. Another modification of the shoe is the insertion of a rigid upper, made of leather similar to that of the counter. In order to prevent a break which would defeat its purpose, the rigid upper is secured to the normal counter of the shoe. The uppers must either be cut out or molded over the ankle bones to prevent pressure.

Modifications in the region of the big toe joint include making the sole sufficiently rigid to prevent motion in the big toe joint. This may relieve the pain in cases of arthritis of that joint.

One of the most valuable emergency measures for relieving painful pressure areas of the feet is splitting or cutting out sections of the shoe. This is especially helpful in cases of injuries, bursitis, ingrown toenails and gout. A patch-pocket is made by cutting out a section of leather and lining and covering the opening with a large patch of thin kid.

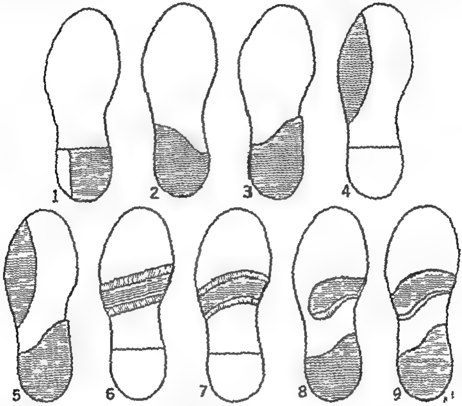


FIG. 40.—Various types of shoe modifications or adjustments. Sole of right shoe shown. *1* Elevation of inner border of heel. *2* Reversed Thomas heel. *3* H. O. Thomas heel—inner border prolonged and elevated. *4* Elevated outer border of sole. *5* Combined Thomas heel and elevated outer border of sole (flexible shank). *6* Robert Jones metatarsal bar (anterior heel). *7* Lewin rubber metatarsal crescent. *8* Thomas heel plus Hauser metatarsal comma bar (flexible shank). *9* Thomas heel plus Lewin tilted notched rubber metatarsal crescent (flexible shank). In making the Thomas or orthopædic heel certain definite measurements must be made from os calcis to inner border of scaphoid and from the outer border of os calcis to the anterior border of the external malleolus. The heel is higher on the inner border usually $\frac{1}{8}$ inch. Thomas designed this sixty five years ago and nobody has improved on it. Many have tried. Here is an illustration of my attempt. It took a long time to find out that in order to tip the heel outward and the sole inward you have to remove the metal shank of the shoe. Every Army shoe has a built in metal shank, therefore you cannot use it for this type of correction unless the shank is removed.

A "dutchman" is a beveled piece of leather between layers of heel or sole.

A football shoe with cleats plus a leather sole will take the place of a patten.

See page 102 for a prescription blank for the modification of shoes.

The internal modifications of shoes include inserts, steel bars, rigid

uppers, the removal of toe caps, the removal of counters, patch pockets, "cookies" and pressure pads.

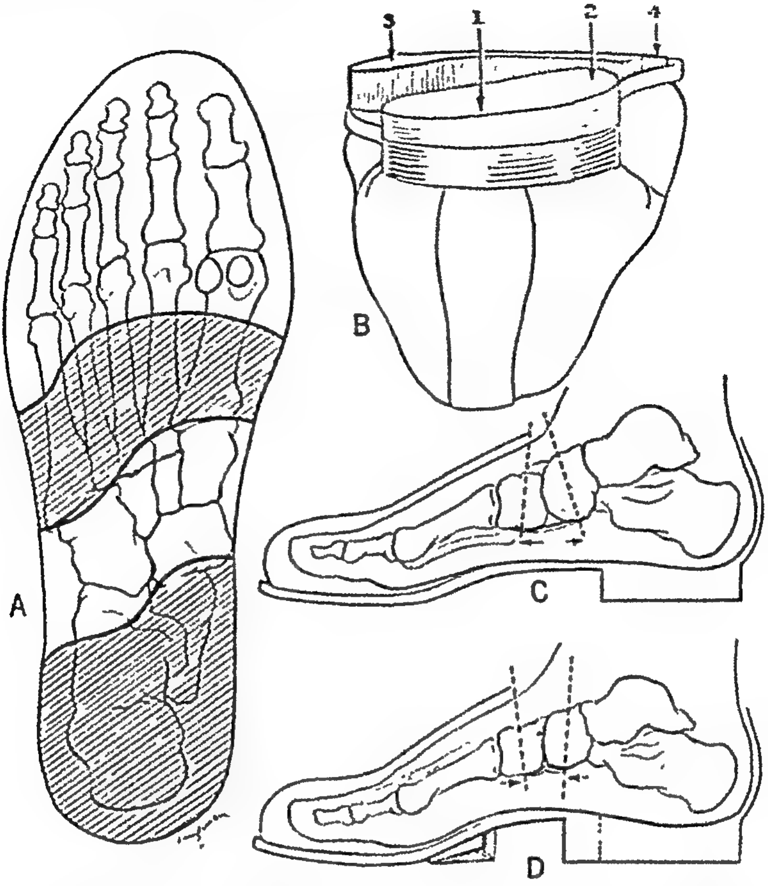


FIG. 41.—*A*. Thomas heel combined with notched, tilted metatarsal crescent attached to a flexible shank shoe. *B*. Numbers 1–2–3–4 indicate sequence of weight bearing areas in making a step. *C*. Relation of scaphoid and first cuneiform bones and their plantar ligament in pronated foot. *D*. Corrected relation of scaphoid and cuneiform bones and their plantar ligament.

Indications for external modifications of shoes depend upon the type of corrective support needed for the establishment of correctly distributed weight-bearing. These modifications consist chiefly of tilting the heel or sole or both, toward the inner or outer border, or shifting the weight from painful weight-bearing areas.

Felt Pads.—The functions of pads are to support and to relieve pressure. I use them under the longitudinal and metatarsal arches and for bunions, hallux valgus, and bunionettes. I pad the tongues of the shoes, the heels, and the point where the vamp breaks in walking.

Felt may be obtained in sheets. It is cut to the proper shape or is stamped out in special shapes by means of dies. It is then beveled with a large 7- or 10-inch blade so that there are no high ridges. The beveling must be done carefully so that there will be irregularities. Ordinary rubber cement is applied felt or with a

large brush When both films are absolutely dry, adhesion will be perfect

Additional pieces of felt can be applied later The chief objection to felt is that it packs down This is actually a virtue because, on account of its resiliency, it acts as a flexible support and is more comfortable than rigid material Usually a pair of shoes requires

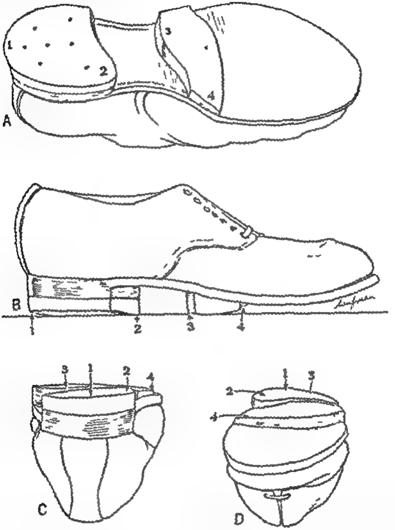


FIG 42 —Thomas heel with Lewin metatarsal crescent *A* oblique view of sole of shoe *B* side view of sole of shoe *C* rear view of heel and sole *D* front view of sole and heel *A* Thomas heel combined with notched tilted metatarsal crescent attached to a flexible shank shoe *B* numbers 1–2–3–4 indicate sequence of weight bearing in making a step (Courtesy of Am Jour Surg)

only one series of pads, but some shoes require two The pad can be altered in shape, size, thickness, and position with relation to the foot and shoe at a moment's notice The only just objections to it are its non-transferability and its compression

The equipment consists of a bench with a bread board, several butcher knives, and a round steel sharpener The knives are sent to a

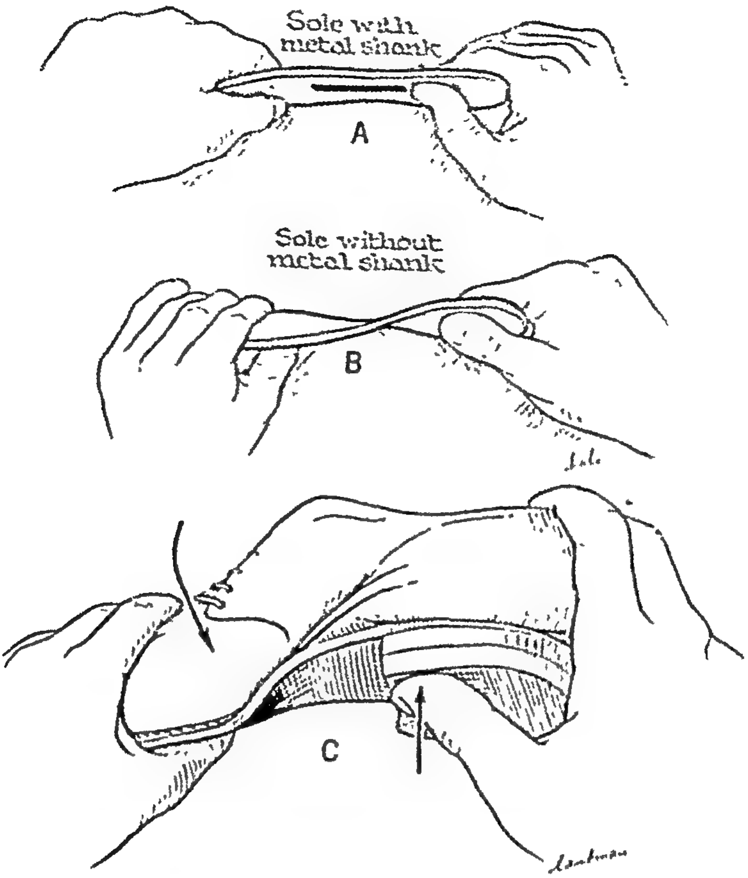


Fig. 43.—*A*, Inability of the shank of a shoe to derotate in a corrective manner while it has a metal shank. *B*, Derotation or detortion of a flexible shanked shoe. *C*, Illustrating the derotating effect of the modified heel and metatarsal crescent.

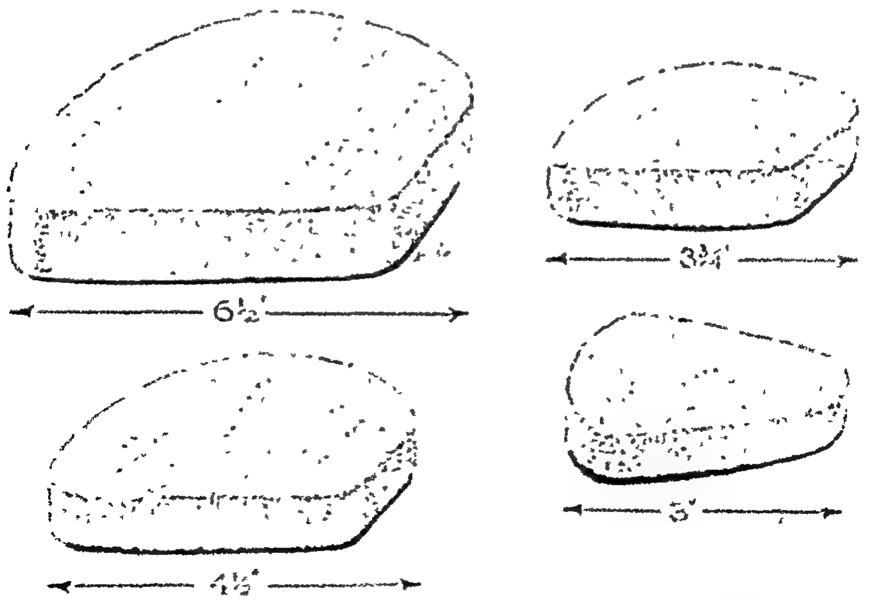


Fig. 44.—Various shapes and sizes of felt pads stamped out by author's dies. Two upper and lower left, for longitudinal arch; lower right for metatarsal arch.

grinder occasionally I have designed dies for stamping out longitudinal and transverse arch pads, but I bevel each one

Indications for internal modifications of shoes are mainly determined by the necessity for supporting the longitudinal or transverse arch and providing relief from painful weight-bearing areas

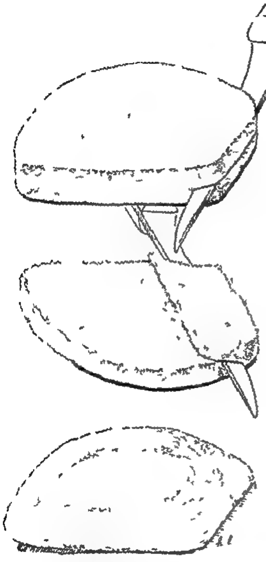


Fig 45 —Beveling felt pads for longitudinal arches by means of large knife

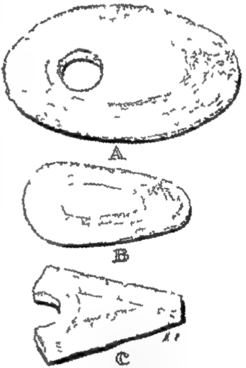


Fig 46 —*A* Bunion pad *B* Metatarsal pad *C* Hard corn pad

Other Arch Supports —The materials used to make arch supports include metal, celluloid, rubber, plastics and felt The metals are German silver, aluminum, duralumin, and monel In order to fashion these, a lead block secured in an anvil and a ball peen hammer are necessary Celluloid is used in two forms large sheets and a thick cream made by dissolving scraps of celluloid in acetone In using sheet-celluloid the pattern is cut and after it has been softened by submersion in boiling water, it is removed and molded over a plaster cast of the foot, with hands that are protected by heavy rubber gloves When celluloid cream is used, crinoline or stockinet is

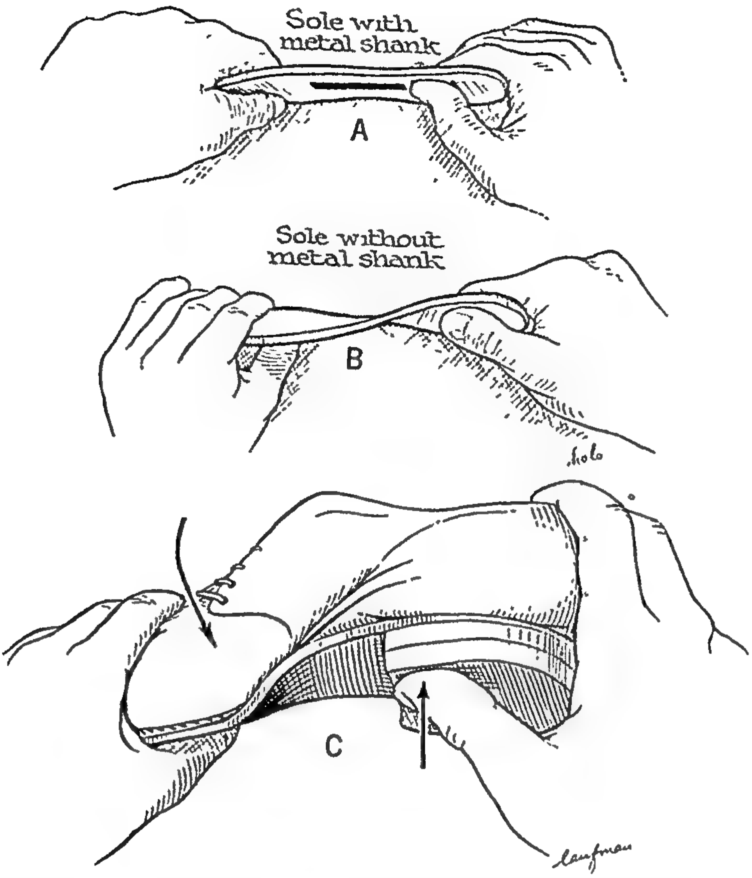


FIG. 43.—*A*, Inability of the shank of a shoe to derotate in a corrective manner while it has a metal shank. *B*, Derotation or detortion of a flexible shanked shoe. *C*, Illustrating the derotating effect of the modified heel and metatarsal crescent.

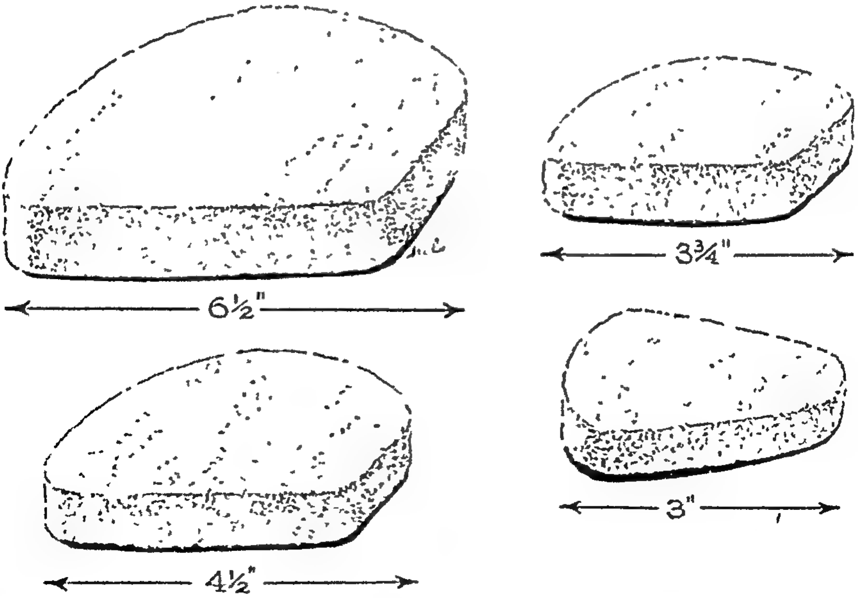


FIG. 44.—Various shapes and sizes of felt pads stamped out by author's dies Two upper and lower left, for longitudinal arch; lower right for metatarsal arch

grinder occasionally I have designed dies for stamping out longitudinal and transverse arch pads, but I bevel each one

Indications for internal modifications of shoes are mainly determined by the necessity for supporting the longitudinal or transverse arch and providing relief from painful weight-bearing areas

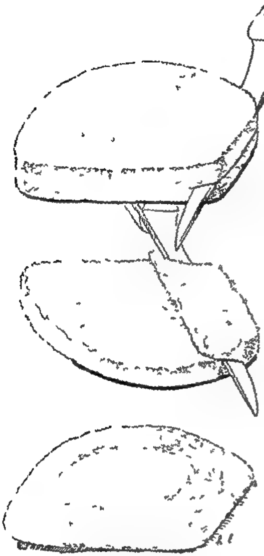


Fig 45 —Beveling felt pads for longitudinal arches by means of large knife

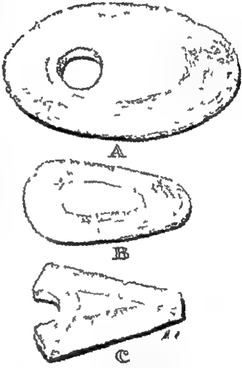


Fig 46 —*A* Bunion pad *B* Metatarsal pad *C* Hard corn pad

Other Arch Supports —The materials used to make arch supports include metal, celluloid, rubber, plastics and felt The metals are German silver, aluminum, duralumin, and monel In order to fashion these, a lead block secured in an anvil and a ball peen hammer are necessary Celluloid is used in two forms large sheets and a thick cream made by dissolving scraps of celluloid in acetone In using sheet-celluloid the pattern is cut and after it has been softened by submersion in boiling water, it is removed and molded over a plaster cast of the foot, with hands that are protected by heavy rubber gloves When celluloid cream is used, crinoline or stockinet is

impregnated with the cream which is applied to it in successive layers. "Moving-picture glue" is sometimes employed for this purpose.

A supersaturated solution of calcium chloride in very hot water added to the celluloid renders the mixture non-inflammable.

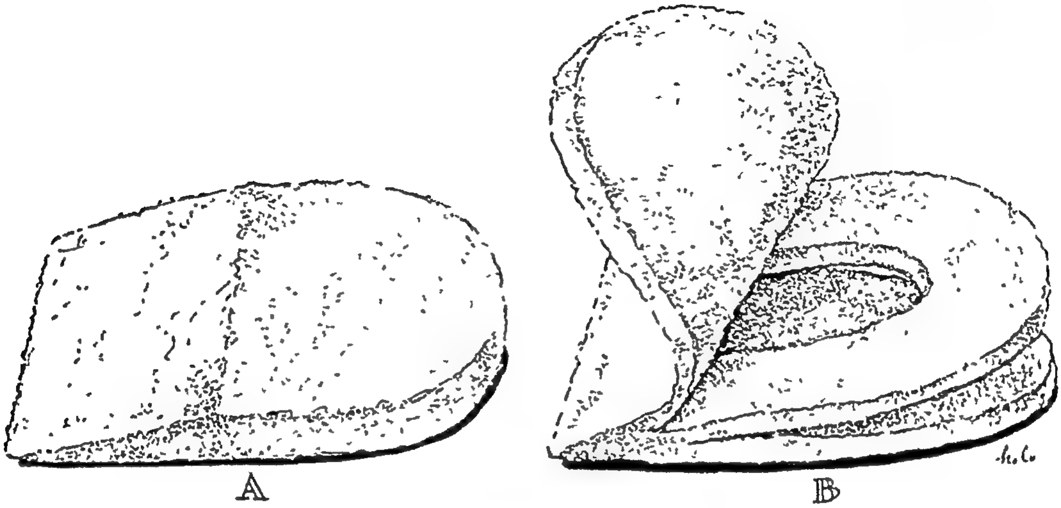


FIG. 47.—*A*, Heel cushion pad. *B*, Calcaneal-spur pad; hole cut in middle section

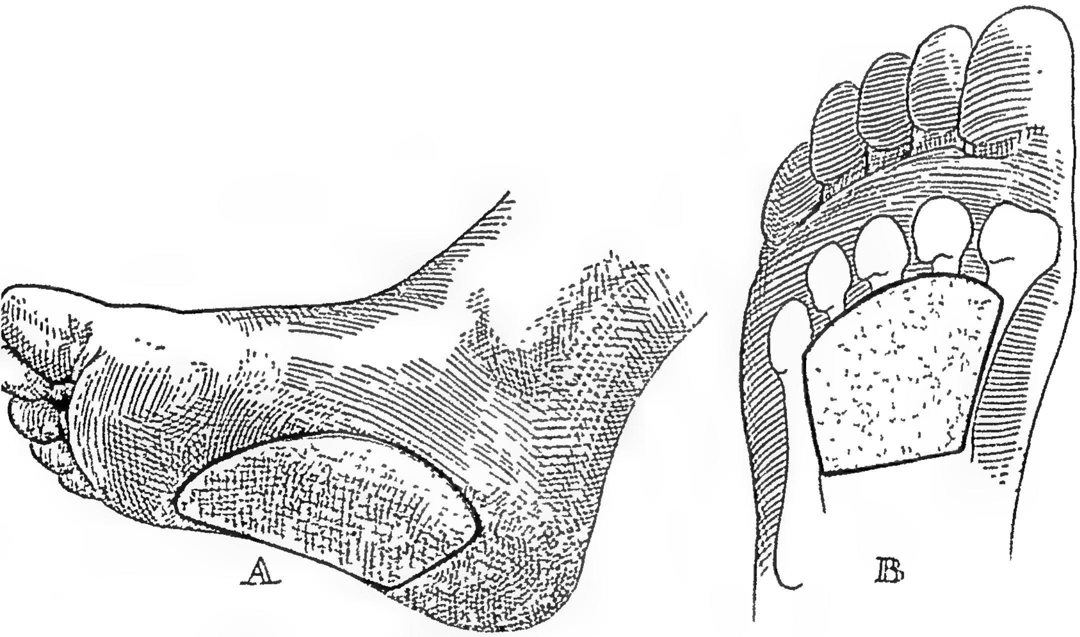


FIG. 48.—*A*, Relation of a beveled felt pad to the longitudinal arch. *B*, Relation of a beveled felt pad to the heads and shafts of metatarsal bones

Rubber is used both raw and molded. It can be obtained in sheets of hard rubber, soft rubber, and sponge rubber. It is cut, trimmed, and either filed or put on the emery wheel. Wood is used in very thin layers of various thicknesses. Most of these materials can be employed

with or without a covering of leather or an insole In order to make a corrective appliance one should have a plaster-of-Paris model of the foot, which is trimmed and shaped so that the arch support will exert a corrective force

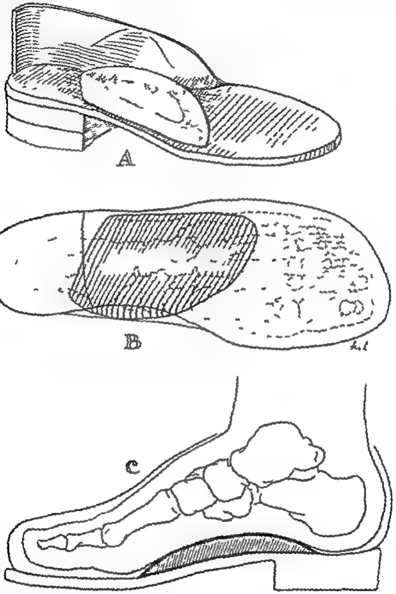


FIG 49 —Longitudinal pad in place in shoe *A*, Relation to shoe *B* Relation to bones plantar view *C* Relation to bones lateral view

A plastic material may be used Morton employs a "pronation control" which extends from under the heel, up against the inner side of the foot in such a manner as to prevent the foot from rolling inward

Metal plates act like crutches They may serve well during a transitional stage, but should be discarded as soon as possible Their removal usually can be accomplished by means of proper shoes, resilient supports exercises, massage, and contrast sprays

The most common modifications of shoes are: (1) elevation of the inner border of the heel; (2) elevation of the inner border of a flared heel; (3) the H. O. Thomas heel—prolongation forward and elevation of the inner border; (4) elevation of the outer border of the sole; (5) the Thomas heel plus elevation of the outer border of the sole; (6)

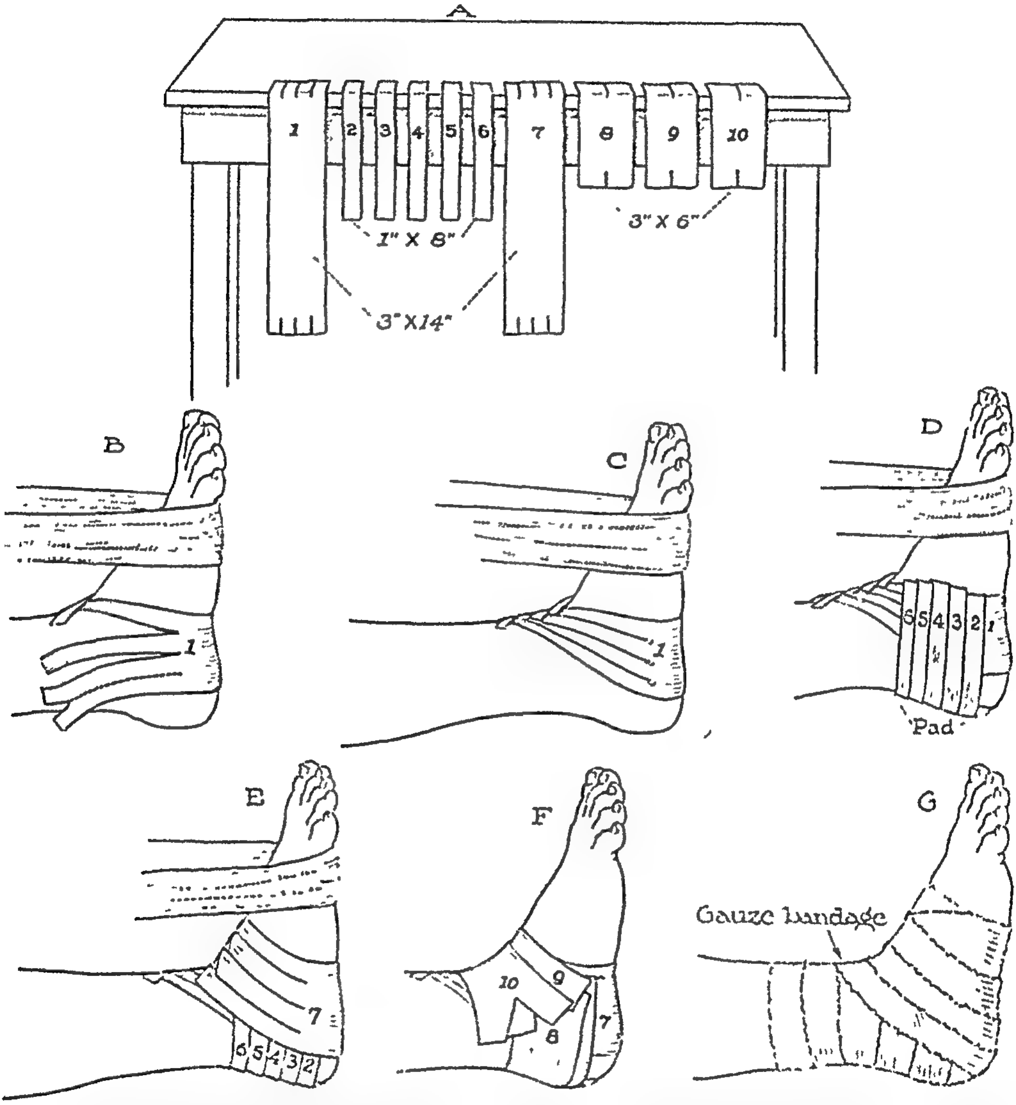


FIG. 50.—Adhesive strapping of ankle. (Strips 1 and 7 should be 18 to 20 inches long, for adults.) I designed this strapping while on duty at Camp Grant, Ill., 1917. (Lewin, Orthopædic Surgery for Nurses, courtesy of W. B. Saunders Company.)

the metatarsal cleat; (7) the metatarsal crescent; (8) the reversed Thomas heel; (9) the modified heel and the metatarsal comma bar; and the notched tilted rubber metatarsal crescent. (See Fig. 41.)

Adhesive Plaster—Its Uses and Technic of Application.—Adhesive plaster strapping is used most commonly in the ambulatory treatment of sprains, strains, and minor fractures, and in the follow-up treatment

of more serious lesions The purposes of strapping are to relieve pain, to limit the movement of an injured or weakened part, to support, to increase stability, to exert compression, to retain a part of the anatomy in the desired position, and to correct minor deformities

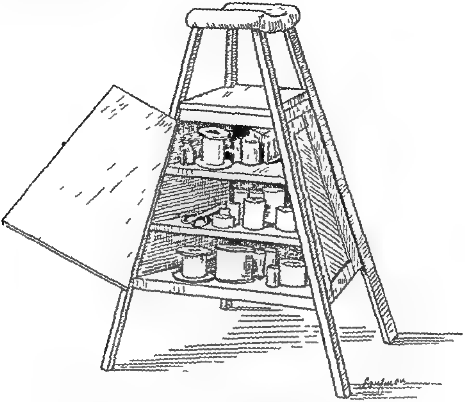


FIG 51 —Combined leg rest cabinet Contents 3- 1- and ½ inch adhesive stockinet 3 inch wide muslin strips for stirrup 1½ inch gauze bandage rubber protectors for bathing bandage scissors compound tincture of benzoin tincture of iodine alcohol cleaning and removing fluid resilient bandages

The various kinds of adhesive are plain, zinc oxide, resinous, Shiver's plaster and moleskin Plain or zinc oxide adhesive tape comes in 10-yard rolls, 3 inches, 1 inch, and ½ inch wide There is a roll of adhesive tape ½ inch wide which is useful in the treatment of conditions of the fingers and toes, especially those of children "Drybak" adhesive is waterproof A new kind of adhesive tape called "hypo-allergic adhesive," is supposed to reduce the danger of allergic dermatitis "Tricoplast," "Elastoplast" and "Elastikon" are bandages made of elastic material faced with adhesive The benzoin acts as an extra layer of skin and the adhesive adheres to it instead of the skin It also facilitates removal of the adhesive later One should beware of skin sensitivity to adhesive and to benzoin

Compound tincture of benzoin, or tincture of merthiolate, or metaphen may be applied to the skin before adhesive tape is put on, and will preserve the skin and minimize the danger of irritation

Before the application of adhesive tape, the part should be shav without the use of soap or liquid. The skin must be thoroughly d and free from oil and powder. Where the tape must cover a hai part, its adhesive property can be eliminated by the application o

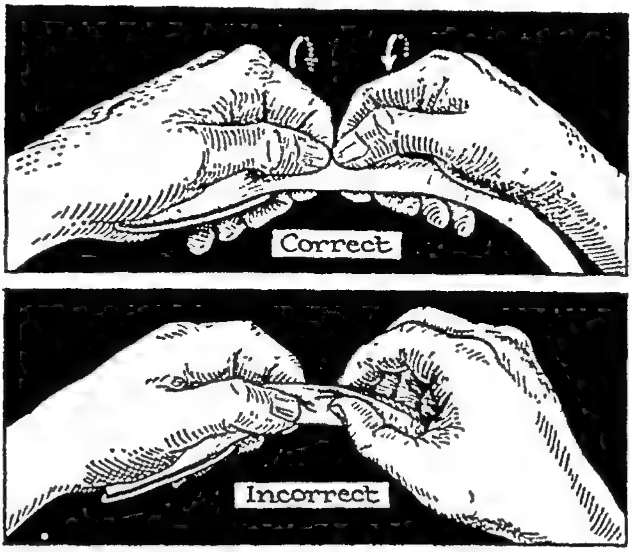


FIG. 52.—Tearing of adhesive plaster. In the absence of scissors, this is read accomplished if the strip of plaster is held between the thumb nails and forefingers, illustrated. The tearing is started by a quick rotary twist of the hands in oppos directions. (Courtesy of Johnson & Johnson.)

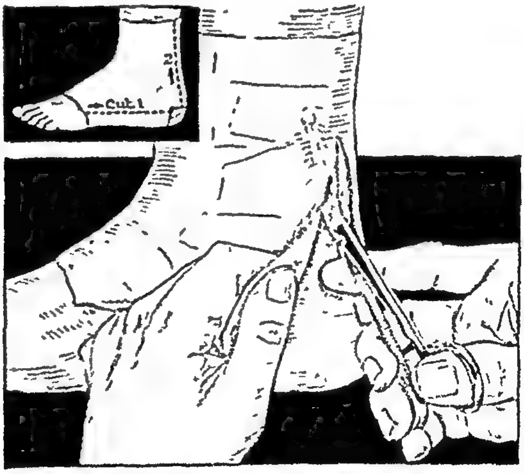


FIG. 53.—The removal of adhesive plaster strappings. It is found necessary exercise as much ingenuity in removal of a strapping as in its application. In the ca of an ankle strapping removal is facilitated by horizontal and vertical cuts with bandn scissors. (Courtesy of Johnson & Johnson.)

piece of gauze, sheet wadding or stockinet so that only the ends the tape will adhere. Adhesive tape can be removed by means ether, benzine, gasoline, energine, carbon tetrachloride, or any of th popular cleaning fluids. After its removal, the part should be gor

over with alcohol or ether and allowed to dry It should then be covered with dusting powder unless another strapping is to be applied

The chief indications for the use of adhesive plaster for foot and ankle conditions are foot strains and sprains, metatarsalgia, rupture of the plantaris tendon, and tendinitis of the Achilles

Prerequisites

1 Immediate application
2 Snug application
3 Restrapping usually in two or three days (after the swelling subsides)

Technic

1 Compound tincture of benzoin
2 Stabilizing strip of bandage like a harness rein
3 Protect dorsal "break" of ankle with stockinet
4 Protect Achilles area with stockinet
5 Adhesive strapping
6 Gauze bandage
7 Rubber pouch for bathing (beware of slipping on soapy bottom of tub)

Ankle Strapping —For the ordinary adult ankle, the following strips are used Two strips of 3-inch adhesive tape each 16 inches long, and four strips 6 inches long, six strips of 1-inch adhesive tape each 10 inches long, and two strips of ½-inch adhesive tape each 16 inches long The two long strips of 3-inch adhesive are nicked three times at each end with a scissors (Fig 50), and by tearing the strips at the nicks four strips are formed The four strips 6 inches long are nicked in the middle at each end The patient sits on a table with the operator sitting on a stool at a lower level The patient holds his foot in the proper position by means of a strip of muslin bandage A strip of muslin is placed over the dorsum of the ankle region The first strip of adhesive to be applied is one of the long 3-inch strips The middle of this is applied to the middle of the sole of the foot, and then, at the site of the little nicks, the ends of the tape are torn into four strips, each one of which is brought over the dorsum of the foot so that it overlaps the one from the other side Then a strip of gauze two layers thick, 2 inches wide, and 6 inches long (or stockinet) is placed lengthwise aver the Achilles tendon and secured in place with a strip of 1-inch odhesive tape which is brought forward on each side of the foot The other 1-inch strips are then applied so that each one overlaps the preceding strip by a half of its width The second long strip of 3-inch adhesive tape is applied slightly farther forward (or backward) than the first one Then the four strips of 6-inch long and 3-inch wide adhesive tape are applied, the first being placed over the heel tendon

and brought forward and each end being split in half. The second layer covers the dorsum of the foot, and the third and fourth layers overlap it half way. A 2-inch roller bandage is then applied and secured by means of two long strips of $\frac{1}{2}$-inch adhesive.

When the skin is sensitive to adhesive tape, irritation can be prevented by using an old silk stocking under the tape or painting a thin

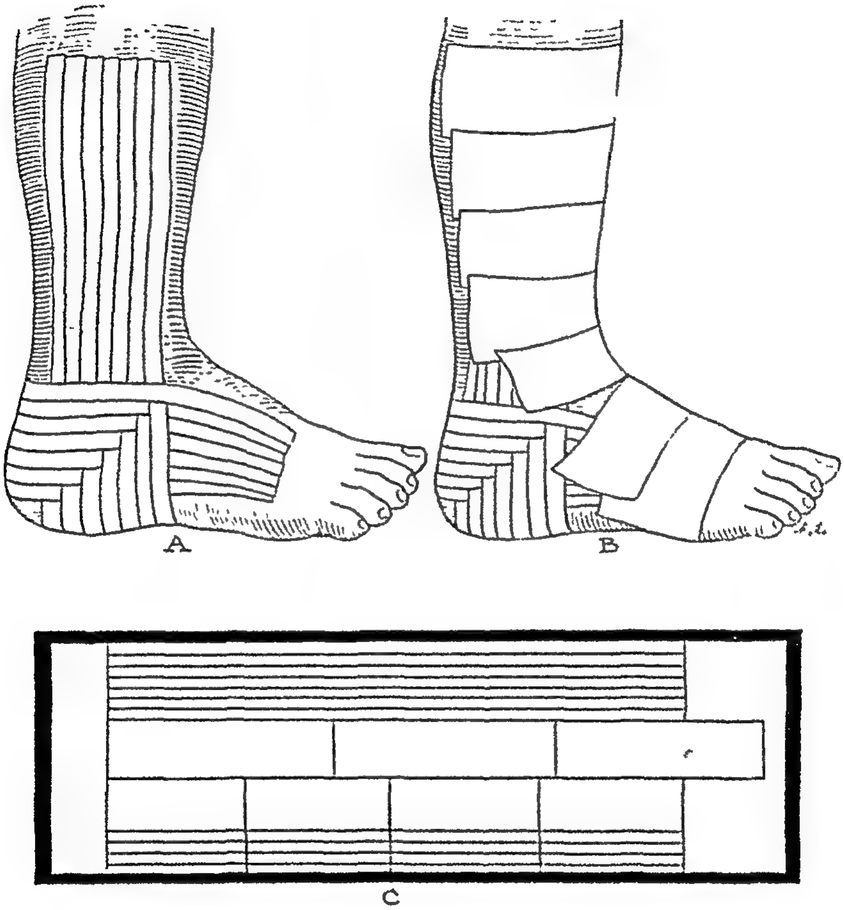


FIG. 54.—Modified Gibney strapping. *A*, Arrangement of the $\frac{3}{4}$-inch strips. *B*, Arrangement of the $3\frac{1}{2}$-inch strips over the narrower strips *C*, Showing how the zinc oxide plaster is marked off preparatory to cutting strips for strapping an adult male patient's foot. Seven strips $\frac{3}{4}$ x 32 in. marked in center. Sixteen strips $\frac{3}{4}$ x 8 in. One piece $3\frac{1}{2}$ x 13 in. One piece $3\frac{1}{2}$ x 12 in. One piece $3\frac{1}{2}$ x 11 in. Four pieces, $3\frac{1}{2}$ x 8 in (Ochsner, courtesy of Medicine.)

film of compound tincture of benzoin on the skin. Pressure over the prominent base of the fifth metatarsal must be avoided.

The adhesive tape can be protected against water by using a pure para-rubber elastic bandage such as the Martin bandage or a large rubber sac while the bath is being taken.

Jones devised an excellent ankle and leg strapping. Other methods bear the names of Gibney and Ochsner. (Fig. 54.)

Os calcis strapping is useful to rotate the os calcis as in flat-foot

and to hold a foot in equinus The strapping should be applied with the patient lying prone or kneeling on a chair (Fig 56) Metatarsal arch strapping consists of the application of 1-inch adhesive plaster transversely, proximal to the first and fifth toe joints while the metatarsal bones are compressed laterally and elevated by pressure from below

Adhesive strapping of the great toe is used to hold the toe straight in cases of hallux valgus A strip ¾ inch wide

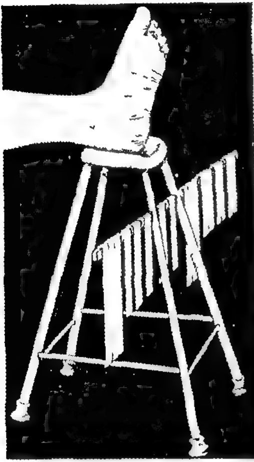


Fig 55 —A simple foot and leg rest for adhesive strapping of foot and ankle (Courtesy of Johnson & Johnson)

Fig 56 —Ankle and leg strapping to protect the Achilles tendon Helpful in some cases of rupture of plantaris tendon and injuries to the calf region

and about 12 inches long is applied on the outer surface of the toe and curves around the end to the inner side It is then secured by two strips placed circularly around the toe With this anchorage the loose end is pulled upon until the toe is straightened, when the end of the adhesive is secured to the inner border of the foot by more transverse strips

Adhesive strapping is beneficial for underriding and overriding toes, especially during infancy and childhood (Fig 163)

Bandages —The Technic of the Application of Bandages —In the application of bandages great care must be taken not to interfere with the circulation In adhesive strappings, complete encirclement of a limb by any one strip should be avoided

Resilient bandages are sold under the names of "Ace," "Tetra," "Adeptic" and "Tensor." They are used in the treatment of minor injuries such as strains and sprains, in cases of more severe injuries after extensive treatment has been given, and in the treatment of certain circulatory disturbances of the extremities.

Cohesive bandages are self-adherent exclusively. They are useful for:

1. Toe dressings.
2. Removable toecap forms.

Elastic supports for the ankle are made of elastic material and are pulled on like a sock. They extend from the bases of the toes to a point a few inches above the malleoli, leaving the toes and heels exposed. Some elastic hose are of knee length. Others extend above the knee. Some expose the heel. They are of value in cases of swelling, edema, or weakness. Their use should be limited in order that the patient may not become dependent upon them. In selected cases they have a definite value for a certain period of time. The purposes of the elastic are to afford compression and mild support and to remind the patient to be cautious. Great care must be taken to prevent elastic compression from interfering with the local circulation. Elastic stockings are beneficial in the treatment of varicose veins and idiopathic edema.

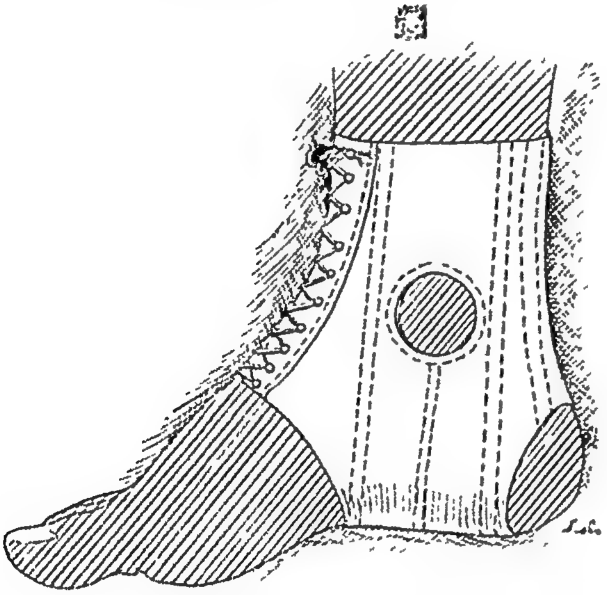


Fig. 57.—Ankle corset or canvas anklet reinforced with whalebone.

The so-called "ankle-corset" is a piece of canvas with eyelets and laces and reinforced with corset steels inserted in narrow slots. It is often of value for weak feet, especially those of persons who wish to engage in certain sports such as ice skating. (Fig. 57.)

Braces—Casts—Splints—Crutches—Other Aids to Locomotion.—The value of splints and braces depends upon the skill and experience of the person who applies them. A splint is as good as the "splinter." The price of success is continuous watchfulness.

Dickson expressed the proper attitude toward braces when he said: "Neither friendship nor braces can be expected to stand up under

the demands of life if poorly chosen and treated with neglect." Lovett said "The best way to avoid wearing a brace permanently is to put it on early and keep it on as long as necessary."

The terms "corrective casts," "corrective splints," and "corrective braces" are, as a rule, misnomers as the apparatus to which they are applied are employed to maintain correction or overcorrection after this has been obtained by such means as manipulation or operation.

The principles as well as the technic of splinting must be thoroughly understood and their importance appreciated by those who undertake the treatment of injuries, diseases, and deformities of the foot and ankle.

In paralytic conditions the purposes of splinting are to protect the weaker muscles against overstretching, to prevent contractures and deformities, and to support a weak foot and ankle.

The three main objectives in the use of mechanical appliances are (1) rest of the part during the healing of diseased or injured tissues, (2) the correction or prevention of deformity, and (3) restoration of the greatest possible degree of function in the shortest possible time.

The splint room should be provided with crutches of all sizes with rubber tips and axillary pads, and canes with rubber tips. Sand bags are made by sewing canvas or heavy ticking in the form of a pillow slip, partially filling them with thoroughly baked sand, and sewing up the free end. Sand bags are used in various sizes, and may be covered with rubber sheeting. They are made round, oval, square or rectangular. They are used in the plaster room, and especially in the operating room. In bed treatment they may be used to support the feet and legs.

FIG. 58.—Short leg brace with rivet joint at ankle. Mayo General Hospital brace shop.

Various shapes and sizes of metal strips and walking irons should be kept in the splint or plaster room. Blocks for raising the heels and soles should also be on hand. The best are made of balsa wood. Cork is light, but expensive, and leather is too heavy.

There are many cases in which no brace will serve exactly the same function as a well-applied plaster-of-Paris cast.

The brace that fits perfectly does not correct a deformity. If a

brace corrects, it exerts pressure with resulting discomfort and the patient or the parents are prone to make adjustments.

The chief braces used in foot and ankle cases are the short and long leg braces, the caliper brace, the brace with a foot plate, the brace with limited motion at the ankle, and the brace with no movement at the ankle.

Ankle braces include those with lock-joint, braces without joints, calipers, and braces with molded foot plates. Foot braces include those mentioned and metal and leather arch supports.

Hoke designed a brace which includes a spring that is attached to the calf band and screwed into the back part of the counter of the heel of the shoe.

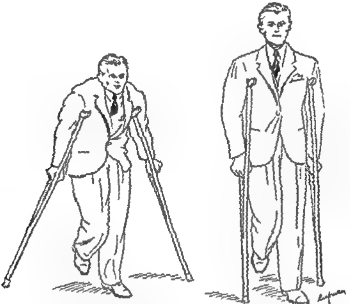
The walking iron is a stirrup or U-shaped apparatus made of cold, rolled steel which has a rubber bar about ½ inch thick riveted to the base of the stirrup. After the foot, ankle, and lower leg are encased in plaster and it is about to set, the iron is fashioned by means of a vise or bar wrenches to the proper shape or position and incorporated in the cast by means of several turns of plaster. For comfortable walking it is necessary that the stirrup part of the walking iron be in the proper position with relation to the antero-posterior length of the foot. (Fig. 63.) A patient with a walking iron cast will be more comfortable if the shoe of the other foot is built up with either leather, rubber, wood, or cork. A simple way of building it up is to attach to the sole and heel an ordinary wooden bath shoe such as is used in gymnasiums and at golf clubs.

Aids to Locomotion.—The various aids to locomotion are: 1 or 2 persons, 2 chairs, 2 canes or crutches, tripods, parallel bars, and special walkers.

Crutches.—The proper length of crutches for adults may be determined by subtracting 16 inches from the height of the patient or by measuring from the axilla to a point 8 inches outward from the outer border of the foot. Crutches are made only in even sizes. If an odd size is required, a crutch of the larger size should be ordered and cut off. The amount that a crutch can be cut off is limited because shortening disturbs the relationship between the axillary rest and the handle. The length of crutches for children is determined by measuring from the axilla to a point about 8 inches out from the foot. Rubber tips should be applied to the lower ends, and pads should be added to the axillary bar to prevent irritation and crutch palsy. I described an adjustable spring crutch which is constructed with telescopic metal sleeves containing plugs and shock-absorbing recoil springs. Special soft resilient slip-over rubber pieces with cells on the under side make excellent axillary pads.

If a patient is allowed to walk with both legs, the proper method of

progression is to place one crutch forward, then the opposite foot, then the second crutch, and then the remaining foot If a patient walks with crutches and one leg, he should put both crutches forward and then the leg The other leg should be held flexed or, preferably, a block should be placed under the shoe (heel and sole) on the unaffected side to keep the injured part off the ground without tilting the pelvis and spine In walking, a patient must maintain the crutches at a proper distance from the body He must learn also to walk with the proper step That is, if he is allowed to bear weight on both feet he should take a step of the same size with each foot so that the heel of the right foot will be at the same level as the toes of the left, and then



A B

FIG 59 —*A* Poor posture in using crutches *B* Good posture The progression if both legs are to be used should be as follows 1, put right crutch forward 2 put left foot forward 3 put left crutch forward 4 put right foot forward *i e* first a crutch then the opposite foot All steps with crutches and feet should be of equal length instead of a long and then a short step

put the heel of the left foot to the level of the toes of the right foot In this way he will learn to make equal steps with both feet The steps can be gradually lengthened

For the method of teaching a patient to use crutches, to get up from a chair, to sit down, to swing through doors, to climb stairs, and to walk sideways and backwards, the reader is referred to Wright's article on "Crutch Walking as an Art"

Brachial cuff crutches are made from ordinary crutches by removing the axillary crutch and attaching a wide leather cuff through which the patient's hand and arm may be passed Their function lies midway between that of the ordinary crutch and that of a cane Wooden

"horses" may be used for walking. In certain cases parallel bars are useful. Special walking apparatus is illustrated in Fig. 30.

Plaster-of-Paris Technic.—The surgeon should be expert in the use of plaster-of-Paris, because serious circulatory disturbances may arise from pressure or constriction produced by an ill-fitting cast.

Equipment of the Plaster Room

The standard equipment of the plaster room includes:

1. Crinoline or tarlatan which is gauze stiffened with a sizing of starch or dextrin.
2. Stockinet or underwear material in rolls of various widths.
3. Sheet-wadding in 3-yard rolls.
4. Felt in sheets from $\frac{1}{16}$ to 1 inch in thickness.
5. Bandages of gauze, muslin, eiderdown, flannel or crepe paper.
6. Splint boards and metal strips, narrow and thick, wide and thin.
7. Plaster-of-Paris, or gypsum, of the rapidly and the slowly setting types.
8. White enameled buckets holding 3 gallons, and bucket stands.
9. Tools for removing casts: a fish knife, a shirt-cutter's knife, a rubber-bulb syringe, spreaders, large dressing scissors, and a carborundum sharpening stone. The Stille cast cutters and Stryker electric saw are recommended.

The Making of Plaster-of-Paris Bandages.—**Materials.**—The materials used in making a plaster-of-Paris bandage are crinoline and plaster-of-Paris powder. The mesh of crinoline most commonly employed is 32 by 28. There are two general types, starch-sized and non-starch-sized. Plaster-of-Paris, or gypsum, varies according to its geographic origin. Chemically, it is calcium sulphate, which occurs in the form of colorless, transparent crystals. The crinoline is torn into 3-, 4-, 5-, and 6-inch widths, and 3-, 4-, 5-, and 6-yard lengths. The selvage and ravelings should be removed.

Procedure.—Where few bandages are used they are made by the nurse or orderly. A strip of crinoline is spread out on a table and sifted plaster-of-Paris is applied and rubbed thoroughly into the meshes with the gloved hand. The strip is then rolled up. Successive strips are similarly prepared until the entire length of crinoline has been used. Oppenheimer's electric roller is recommended.

Commercial Bandages.—The "Specialist" bandage contains no loose plaster, becomes saturated immediately upo [illegible] mersed in water, and is highly re[illegible]. Before it is i[illegible] may be cut into short or narrow [illegible] casts to be [illegible] ew-born babies with club-feet a[illegible] he fingers of [illegible] s of 1 inch and 1½ inches, and l[illegible] hes are des[illegible] andage comes also in sheets for [illegible]

Storage of Bandages —The rolled bandages should be kept on their sides in a metal box The cover of the box should be removed only when bandages are being put in or taken out The box should not be shaken Bandages may be wrapped in paper napkins

Soaking the Bandages —A white enameled bucket is filled two-thirds full of lukewarm water, and the rolled bandage is immersed on its side When air bubbles cease to appear, the bandage is removed

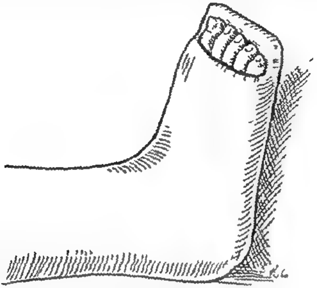


FIG 60 —Prolongation of sole of plaster cast beyond toes in order to act as a cradle to keep covers off the toes

Squeezing the Bandage —The bandage is grasped at both ends to prevent the escape of much plaster, and by a twisting movement the excess is expressed By a reverse twist, the bandage is straightened, and by "patting" it is made flat The end is found and unfolded for a distance of only 3 inches The bandage is then ready for application

The Application of the Plaster-of-Paris Bandage —The plaster bandage is applied as any other bandage, care being taken not to constrict The course of the bandage is more easily changed than that of a muslin bandage because a tuck or gusset may be made (Reversing or turning the bandage is not good practice) A gusset is a "cut out," a tuck is an "overlap" As the turns of the bandage are applied, the plaster is firmly rubbed in so that a homogeneous mass, instead of a series of layers, is produced (Fig 62)

Setting —Plaster may be "slow setting" or "quick setting" Slow-setting plaster can be made to set more rapidly by the addition of a handful of table salt or alum to the aforementioned 2 gallons of water Gelatin or glue retards the setting of plaster A plaster cast enlarges as it sets

A plaster cast is applied (1) to hold a foot and ankle at rest, (2)

"horses" may be used for walking. In certain cases parallel bars are useful. Special walking apparatus is illustrated in Fig. 30.

Plaster-of-Paris Technic.—The surgeon should be expert in the use of plaster-of-Paris, because serious circulatory disturbances may arise from pressure or constriction produced by an ill-fitting cast.

Equipment of the Plaster Room

The standard equipment of the plaster room includes:

1. Crinoline or tarlatan which is gauze stiffened with a sizing of starch or dextrin.
2. Stockinet or underwear material in rolls of various widths.
3. Sheet-wadding in 3-yard rolls.
4. Felt in sheets from $\frac{1}{16}$ to 1 inch in thickness.
5. Bandages of gauze, muslin, eiderdown, flannel or crepe paper.
6. Splint boards and metal strips, narrow and thick, wide and thin.
7. Plaster-of-Paris, or gypsum, of the rapidly and the slowly setting types
8. White enameled buckets holding 3 gallons, and bucket stands.
9. Tools for removing casts: a fish knife, a shirt-cutter's knife, a rubber-bulb syringe, spreaders, large dressing scissors, and a carborundum sharpening stone. The Stille cast cutters and Stryker electric saw are recommended.

The Making of Plaster-of-Paris Bandages.—**Materials.**—The materials used in making a plaster-of-Paris bandage are crinoline and plaster-of-Paris powder. The mesh of crinoline most commonly employed is 32 by 28. There are two general types, starch-sized and non-starch-sized. Plaster-of-Paris, or gypsum, varies according to its geographic origin. Chemically, it is calcium sulphate, which occurs in the form of colorless, transparent crystals. The crinoline is torn into 3-, 4-, 5-, and 6-inch widths, and 3-, 4-, 5-, and 6-yard lengths. The selvage and ravelings should be removed.

Procedure.—Where few bandages are used they are made by the nurse or orderly. A strip of crinoline is spread out on a table and sifted plaster-of-Paris is applied and rubbed thoroughly into the meshes with the gloved hand. The strip is then rolled up. Successive strips are similarly prepared until the entire length of crinoline has been used. Oppenheimer's electric roller is recommended.

Commercial Bandages.—The "Specialist" bandage contains no loose plaster, becomes saturated immediately upon being immersed in water, and is highly recommended. Before it is immersed, it may be cut into short or narrow pieces. For casts to be applied to new-born babies with club-feet and casts for the fingers of adults, widths of 1 inch and $1\frac{1}{2}$ inches, and lengths of 24 inches are desirable. This bandage comes also in sheets for making splints.

Storage of Bandages —The rolled bandages should be kept on their sides in a metal box The cover of the box should be removed only when bandages are being put in or taken out The box should not be shaken Bandages may be wrapped in paper napkins

Soaking the Bandages —A white enameled bucket is filled two-thirds full of lukewarm water, and the rolled bandage is immersed on its side When air bubbles cease to appear, the bandage is removed

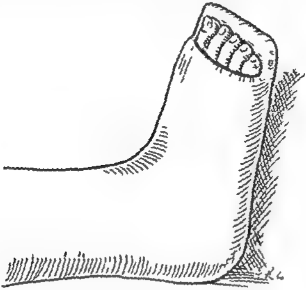


Fig 60 —Prolongation of sole of plaster cast beyond toes in order to act as a cradle to keep covers off the toes

Squeezing the Bandage —The bandage is grasped at both ends to prevent the escape of much plaster, and by a twisting movement the excess is expressed By a reverse twist, the bandage is straightened, and by "patting" it is made flat The end is found and unfolded for a distance of only 3 inches The bandage is then ready for application

The Application of the Plaster-of-Paris Bandage —The plaster bandage is applied as any other bandage, care being taken not to constrict The course of the bandage is more easily changed than that of a muslin bandage because a tuck or gusset may be made (Reversing or turning the bandage is not good practice) A gusset is a "cut out," a tuck is an "overlap " As the turns of the bandage are applied, the plaster is firmly rubbed in so that a homogeneous mass, instead of a series of layers, is produced (Fig 62)

Setting —Plaster may be "slow setting" or "quick setting " Slow-setting plaster can be made to set more rapidly by the addition of a handful of table salt or alum to the aforementioned 2 gallons of water Gelatin or glue retards the setting of plaster A plaster cast enlarges as it sets

A plaster cast is applied (1) to hold a foot and ankle at rest, (2)

to hold it in a certain position, (3) to afford support, and (4) to protect certain soft parts.

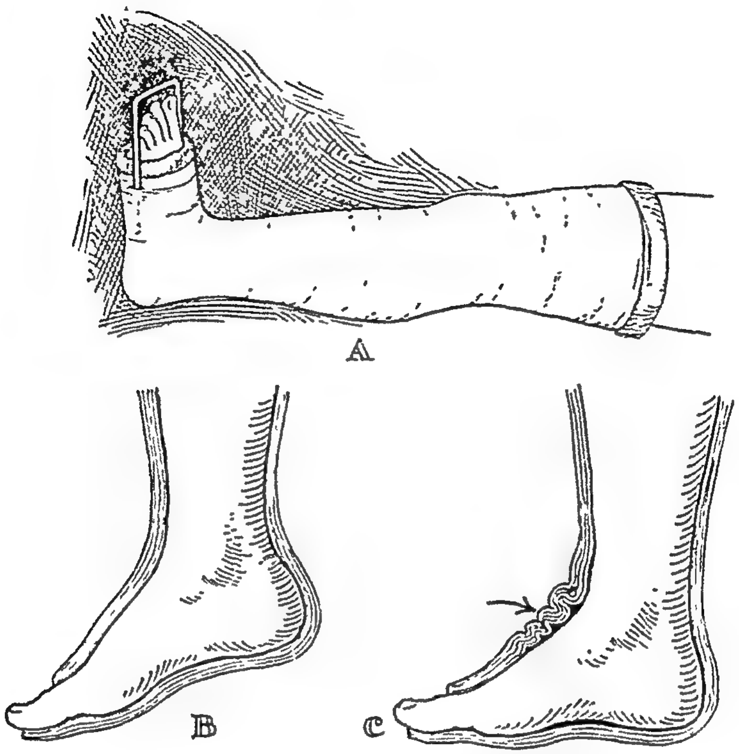


Fig 61.—*A*, Wicket cradle attachment to a plaster-of-Paris cast to protect the toes from the bed coverings. Wire incorporated in cast. *B*, Fresh plaster cast applied while foot was in equinus *C*, After dorsiflexion of foot which produced several harmful wrinkles. (Lewin, courtesy of Jour. Am. Med. Assn.)

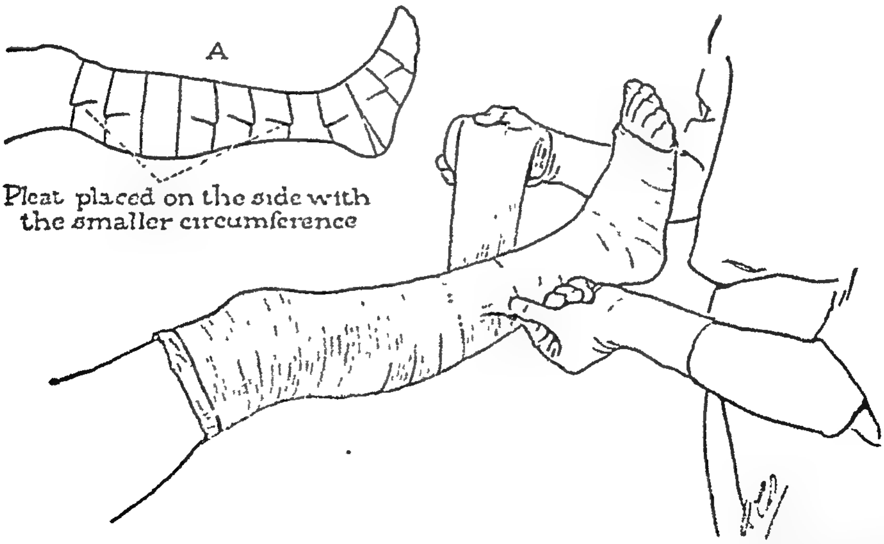


Fig. 62.—Method of applying plaster bandage. These should never be reversed as in the application of a muslin or gauze bandage. (Magnuson's Fractures, courtesy of J. B. Lippincott Company.)

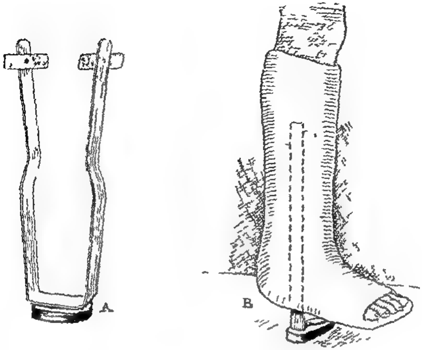


FIG 63 —*A* Walking iron *B* Incorporated in a leg cast

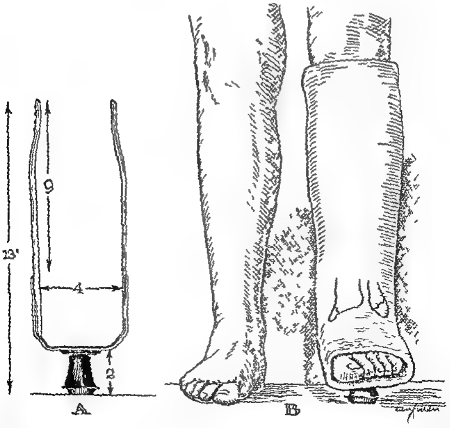


FIG 64 —*A* Walking iron with flexible uprights rigid stirrup and swivel crutch tip *B* Cast with walking iron in position (Redrawn from Larsen courtesy of Surg Gynec and Obst)

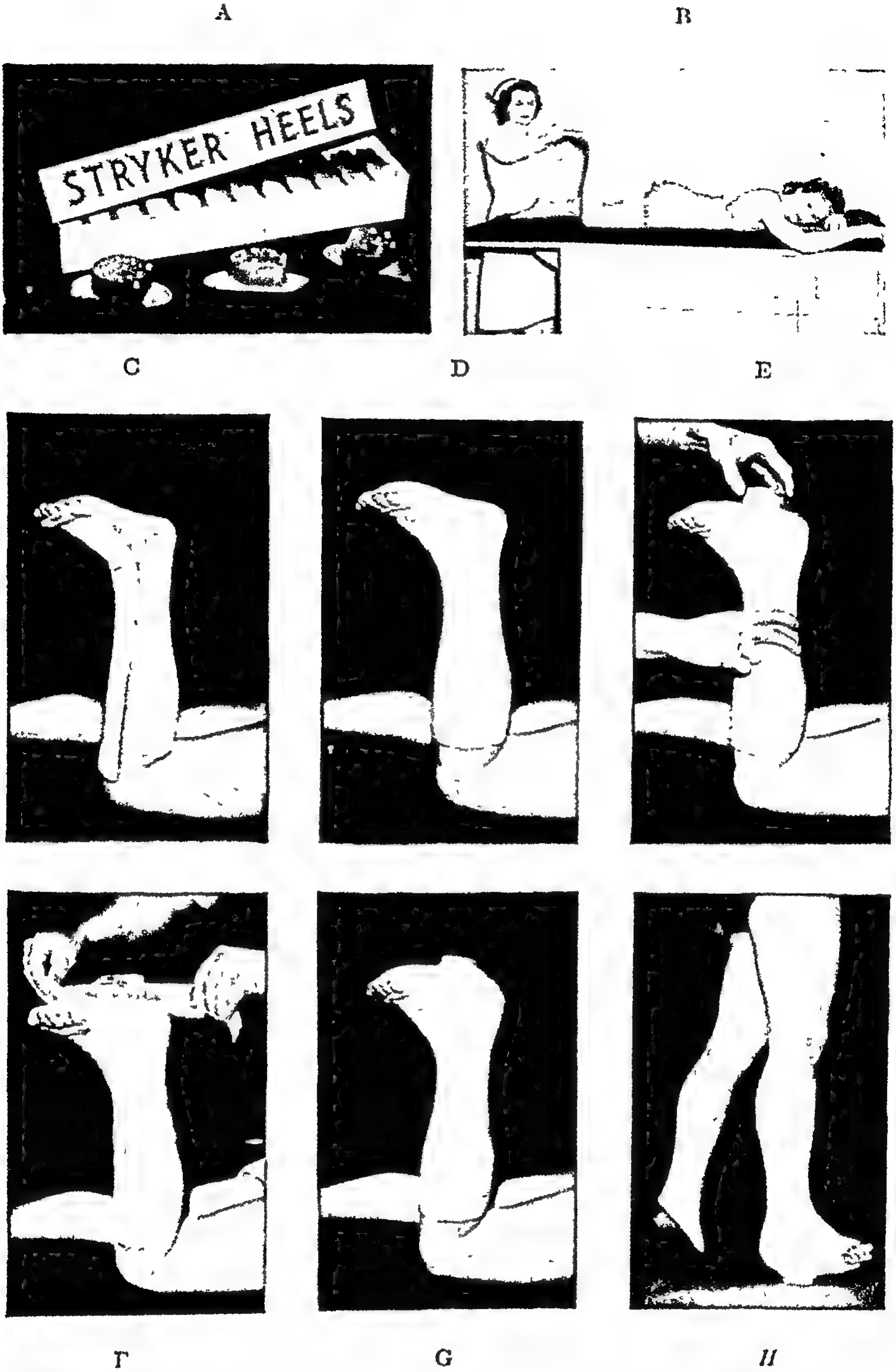


Fig. 65.—*A*, Rubber heels for making casts. *B*, Position of patient which facilitates the application of cast and alignment of heel. *C*, Place patient on abdomen. Paste a 3 inch tube of stockinette to shin with Ace adherent. Mold a 6 layer plaster splint to sole and calf. *D*, Cast is completed with circular plaster—4 rolls 5 inches. Sole is reinforced and leveled with plaster splints. *E*, Heel is molded into the soft plaster at midfoot at right angles to, and in line with the axis of the leg. *F*, Heel is held by a four layer splint folded edge-wise extending from toes around heel and back to toes plus a few turns of circular plaster. *G*, When completed, only curved rubber heel projects beyond cast. *H*, Walking permitted when cast is dry. Rounded rubber heel allows rocker motion in walking. Wool toe cap, sock or overshoe may be worn over cast out of doors in wet or winter weather. (Courtesy of the Orthopedic Frame Company, Kalamazoo, Michigan.)

A good cast must be light of weight, smooth inside, snugly fitting to prevent slipping, and non-constricting All fingers and toes except the fifth toe must be visible to allow ready observation of the circulatory status

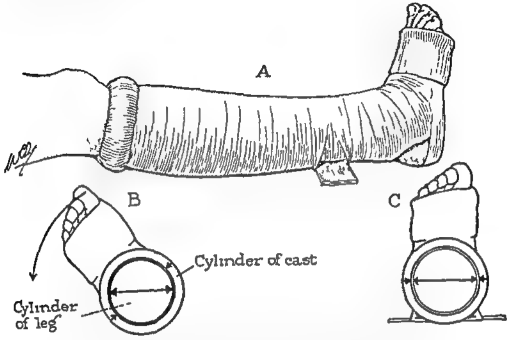


FIG 66 —Method of preventing rotation of the lower leg on the bed after cast is applied A short board is incorporated in the cast if it is difficult to maintain the desired position (Magnuson s Fractures courtesy of J B Lippincott Company)

In the application of plaster to the foot and ankle it is most important that the parts be held in the position in which they are to be immobilized If the position becomes changed before the plaster dries, there will be wrinkles, creases, irregularities, corrugations, and pressure which may result in necrosis and ulcers (Fig 61, *C*) The base of the fifth toe should be well padded and included in the cast because if it is left exposed the edge of the cast will cut into it no matter where the edge may be The prominent base of the fifth metatarsal must also be padded A little felt or sheet-wadding in front or behind it, usually minimizes the prominence, thereby relieving the pressure

While the cast is setting, the longitudinal and transverse arches can be molded The cast can be molded around the os calcis and malleoli so that it will not slip Slipping causes irritation and ulcer When an ulcer forms under a plaster cast, a characteristic odor is noted

Reinforcements —Reinforcements are made of plaster and are called "reverses" They may be made up beforehand They are made in various lengths folded over each other and put away in this shape When they are to be used, they are soaked in water and applied to the cast They can be made as the cast is being applied by laying ordinary plaster bandages back and forth on a smooth surface Reinforcements

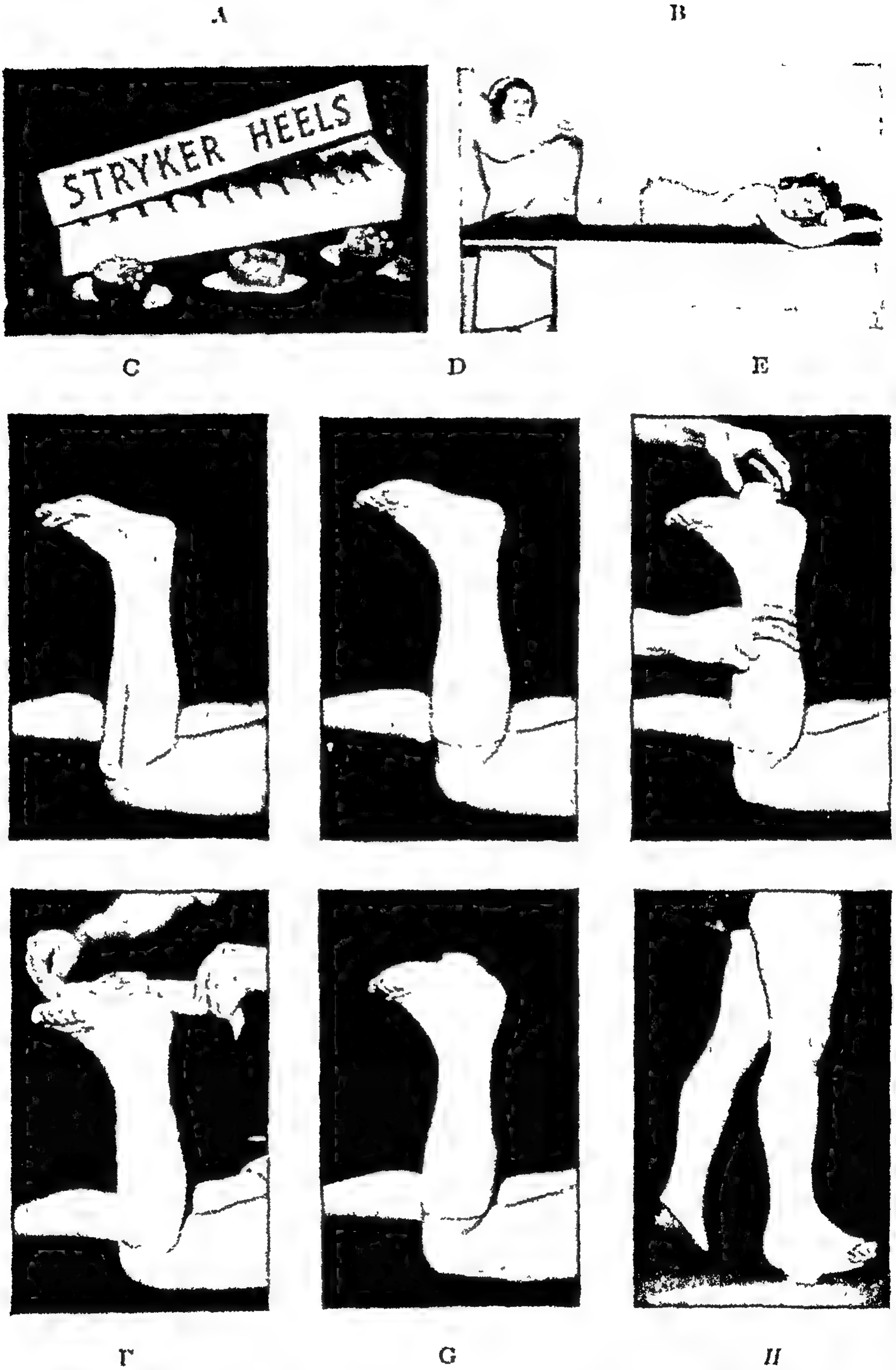


Fig. 65.—*A*, Rubber heels for making casts. *B*, Position of patient which facilitates the application of cast and alignment of heel. *C*, Place patient on abdomen. Paste a 3 inch tube of stockinette to shin with Ace adherent. Mold a 6 layer plaster splint to sole and calf. *D*, Cast is completed with circular plaster—4 rolls 5 inches. Sole is reinforced and leveled with plaster splints. *E*, Heel is molded into this soft plaster at midfoot at right angles to, and in line with the axis of the leg. *F*, Heel is held by a four layer splint folded edge-wise extending from toes around heel and back to toes plus a few turns of circular plaster. *G*, When completed, only curved rubber heel projects beyond cast. *H*, Walking permitted when cast is dry. Rounded rubber heel allows rocker motion in walking. Wool toe cap, sock or overshoe may be worn over cast out of doors in wet or winter weather. (Courtesy of the Orthopedic Frame Company, Kalamazoo, Michigan.)

A good cast must be light of weight, smooth inside, snugly fitting to prevent slipping, and non-constricting. All fingers and toes except the fifth toe must be visible to allow ready observation of the circulatory status.

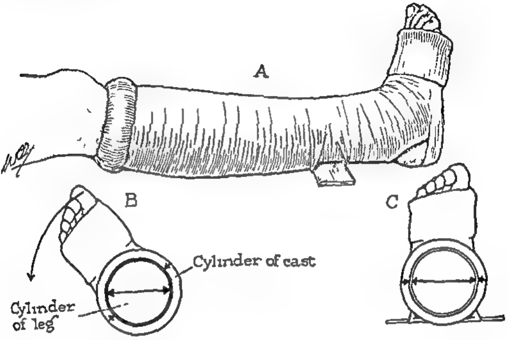


FIG 60.—Method of preventing rotation of the lower leg on the bed after cast is applied. A short board is incorporated in the cast if it is difficult to maintain the desired position. (Magnuson's Fractures, courtesy of J. B. Lippincott Company.)

In the application of plaster to the foot and ankle it is most important that the parts be held in the position in which they are to be immobilized. If the position becomes changed before the plaster dries, there will be wrinkles, creases, irregularities, corrugations, and pressure which may result in necrosis and ulcers (Fig. 61, *C*). The base of the fifth toe should be well padded and included in the cast because if it is left exposed the edge of the cast will cut into it no matter where the edge may be. The prominent base of the fifth metatarsal must also be padded. A little felt or sheet-wadding in front or behind it, usually minimizes the prominence, thereby relieving the pressure.

While the cast is setting, the longitudinal and transverse arches can be molded. The cast can be molded around the os calcis and malleoli so that it will not slip. Slipping causes irritation and ulcer. When an ulcer forms under a plaster cast, a characteristic odor is noted.

Reinforcements.—Reinforcements are made of plaster and are called "reverses." They may be made up beforehand. They are made in various lengths folded over each other and put away in this shape. When they are to be used, they are soaked in water and applied to the cast. They can be made as the cast is being applied by laying ordinary plaster bandages back and forth on a smooth surface. Reinforcements

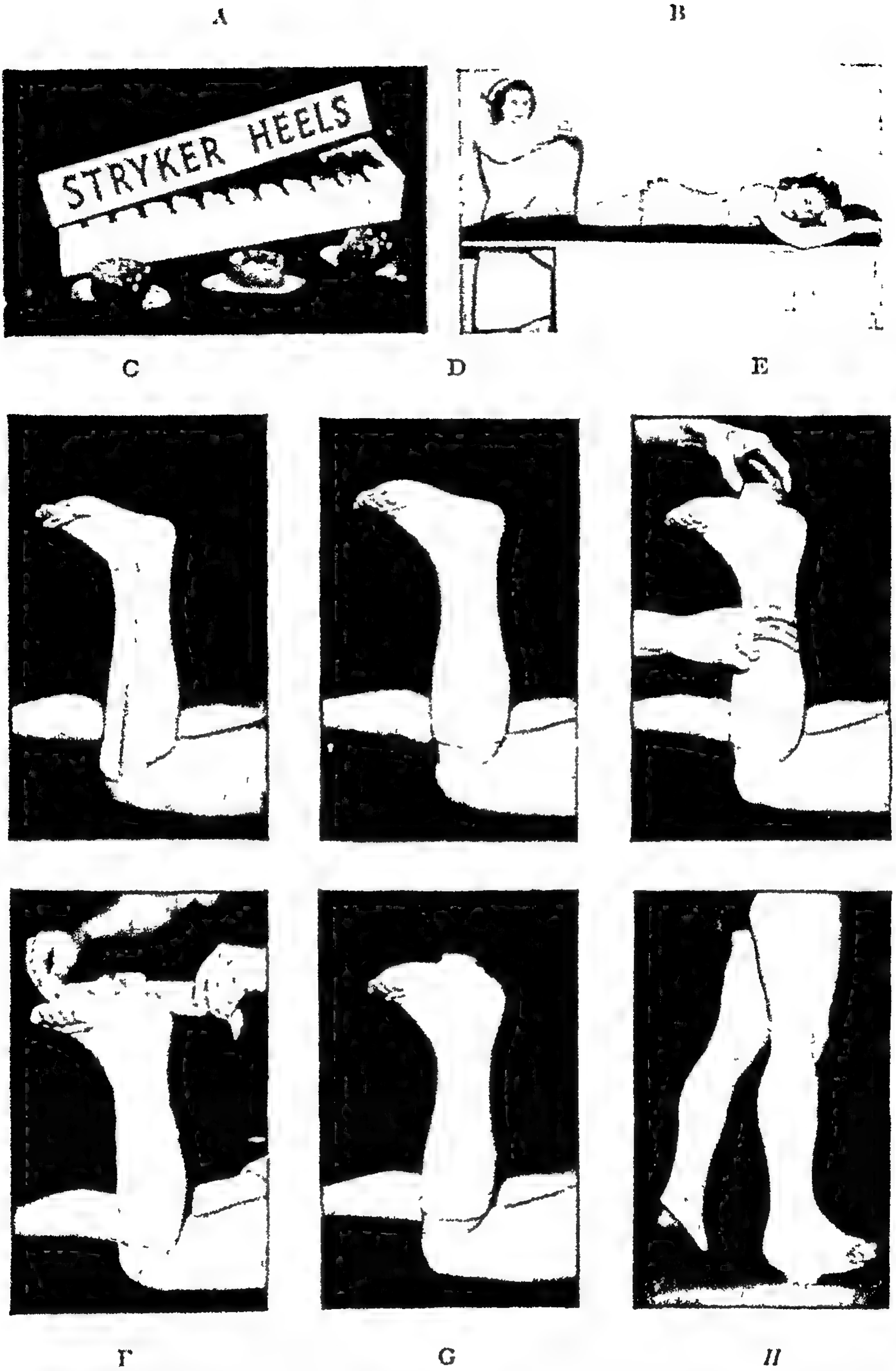


FIG. 65.—*A*, Rubber heels for making casts. *B*, Position of patient which facilitates the application of cast and alignment of heel. *C*, Place patient on abdomen. Paste a 3 inch tube of stockinette to shin with Ace adherent. Mold a 6 layer plaster splint to sole and calf. *D*, Cast is completed with circular plaster—4 rolls 5 inches. Sole is reinforced and leveled with plaster splints. *E*, Heel is molded into this soft plaster at midfoot at right angles to, and in line with the axis of the leg. *F*, Heel is held by a four layer splint folded edge-wise extending from toes around heel and back to toes plus a few turns of circular plaster. *G*, When completed, only curved rubber heel projects beyond cast. *H*, Walking permitted when cast is dry. Rounded rubber heel allows rocker motion in walking. Wool toe cap, sock or overshoe may be worn over cast out of doors in wet or winter weather. (Courtesy of the Orthopedic Frame Company, Kalamazoo, Michigan.)

A good cast must be light of weight, smooth inside, snugly fitting to prevent slipping, and non-constricting. All fingers and toes except the fifth toe must be visible to allow ready observation of the circulatory status.

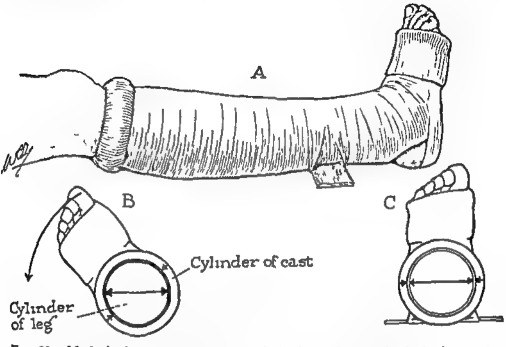


Fig 60.—Method of preventing rotation of the lower leg on the bed after cast is applied. A short board is incorporated in the cast if it is difficult to maintain the desired position. (Magnuson's Fractures, courtesy of J. B. Lippincott Company.)

In the application of plaster to the foot and ankle it is most important that the parts be held in the position in which they are to be immobilized. If the position becomes changed before the plaster dries, there will be wrinkles, creases, irregularities, corrugations, and pressure which may result in necrosis and ulcers (Fig 61, *C*). The base of the fifth toe should be well padded and included in the cast because if it is left exposed the edge of the cast will cut into it no matter where the edge may be. The prominent base of the fifth metatarsal must also be padded. A little felt or sheet-wadding in front or behind it, usually minimizes the prominence, thereby relieving the pressure.

While the cast is setting, the longitudinal and transverse arches can be molded. The cast can be molded around the os calcis and malleoli so that it will not slip. Slipping causes irritation and ulcer. When an ulcer forms under a plaster cast, a characteristic odor is noted.

Reinforcements.—Reinforcements are made of plaster and are called "reverses." They may be made up beforehand. They are made in various lengths *folded over each other and put away in this shape.* When they are to be used, they are soaked in water and applied to the cast. They can be made as the cast is being applied by laying ordinary plaster bandages back and forth on a smooth surface. Reinforcements

such as the yucca board and the peachboard splint are made of wood. Thin strips of metal may be used.

"Finishing" the Cast.—A layer of thick plaster cream is carefully smoothed over the cast as a plasterer would apply it to a wall. The cast is then gone over delicately with a large piece of wet cotton. A wet plaster bandage may be used as a "rubber" or "ironer." Plaster powder may be dusted on the completed cast and rubbed in. Two coats of shellac or varnish may be applied to a dry cast. Celluloid dissolved in acetone to the consistency of thin cream may be painted on a thoroughly dry cast. The dry cast may be covered with stockinet.

Lewin Method.—The last plaster bandage must be creamy. A sheet of dry crinoline is quickly and thoroughly rubbed in. When the plaster is about to set, the cast is rubbed with a rolled-up strip of wet plaster bandage in the manner of shoe-shining. If the last bandage is not creamy, some thin plaster cream is made up in a bowl and the crinoline is impregnated with the plaster and applied.

The date should be marked with an indelible pencil on every plaster cast. The outlines of fractured bones may be sketched on the cast.

Trimming.—An old Bard-Parker knife is excellent for trimming a fresh cast. Trimming is necessary over the ends of the toes. One may allow the fifth toe to remain hidden because if the cast is trimmed at the base of the little toe, the edge will cause pressure at another point and retrimming will usually be necessary. A window is cut in a cast at any point at which dressings are required. The stockinet is cut, turned back over the cast, and fixed in place with adhesive, tacks, or, preferably, strips of plaster bandages.

Protecting the Cast.—The cast may be protected against soiling by means of oiled silk, oiled cloth, cellophane, or gutta percha, or by painting it with celluloid or shellac.

To protect the toes when a foot or leg cast is indicated a cradle effect can be obtained by the application of a wire or plaster rope wicket. (Fig. 61,*A*.) When the cast is complete and just before the stockinet is turned down to make a French cuff, a slit is made on each side of the stockinet. The stockinet is turned back so that it spans each side of the wicket, and two or three turns of plaster are applied to secure the wicket in position. The wicket may be made of No. 12 gauge galvanized wire, shaped by hand, or of plaster rope fashioned by passing a strip of bandage through the partly closed hand. The distance between the ends of the toes and the wicket should be about 1½ inches. To obtain greater stability, the ends of the wire may be curled or bent. The cradle may be made removable. The wicket can be modified to function like a banjo splint. It may be employed in conjunction with a walking iron. The wire of an ordinary coat hanger furnishes excellent material for a wicket.

Sideman devised what I have termed a "plaster-of-Paris windmill" (Fig 68) It is made of two pieces of wood which are riveted at their mid-points, then spread apart so as to have four projections like an X, and then covered with plaster The foot is placed in the superior "Y," and the windmill incorporated in the cast This apparatus is of value from many points of view First and foremost, it stabilizes the foot and leg Second, it elevates the foot and leg, thereby improving circulation Third, it keeps the bedclothes off the toes

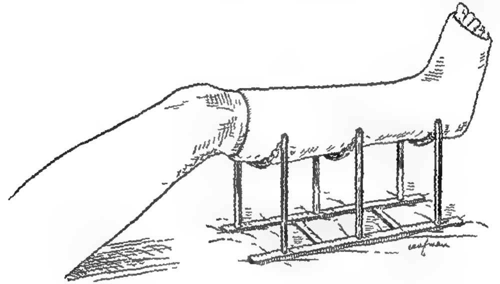


Fig 67 —Leg rest Three chair support Note rubber hose over chair May be used after operations (Modified from Whitman)

Bohler's Non-padded Cast —Bohler claims that a non-padded cast is superior in maintaining reduced fractured fragments in position and allows earlier discharge of the patient from the hospital

Wedging the Cast —If a deformity of the ankle is to be corrected, a cast is applied with the ankle in the most comfortable position When the cast is set (at the end of one or two days), a transverse cut is made over the dorsum of the ankle and extending about two-thirds of the way around so that only the anterior third is left intact Then, by means of gentle pressure above and below, and as quickly as possible, the gap is enlarged and held by means of tongue depressors placed edgewise in the gap or by a wedge of wood After several days a few turns of plaster bandage hold the ankle in the corrected position This process may be repeated in the gradual correction of a deformity Angulation of fragments in a fracture can be corrected by wedging casts (Fig 69)

Precautions to be Observed —A hardening cast should not rest on a hard surface In order to prevent wrinkling within the cast, which would cause pressure, all correction of position should be accomplished before the plaster has hardened (Fig 61, C) When the patient

is taken from the plaster room to his bed, the cast should be left uncovered until it is thoroughly dry. An outpatient should be detained until the cast is dry. An electric drier saves time. A few other rules to be observed are the following: (1) Protect bony prominences. (2) Mold the cast to the outline of the part to which it is applied. (3) Do not reverse plaster bandages. (4) Be sure that all toes except the fifth toe are visible. (5) Be sure there is no constriction of the circulation. If there is any question, split and spread the cast. (6) Bear

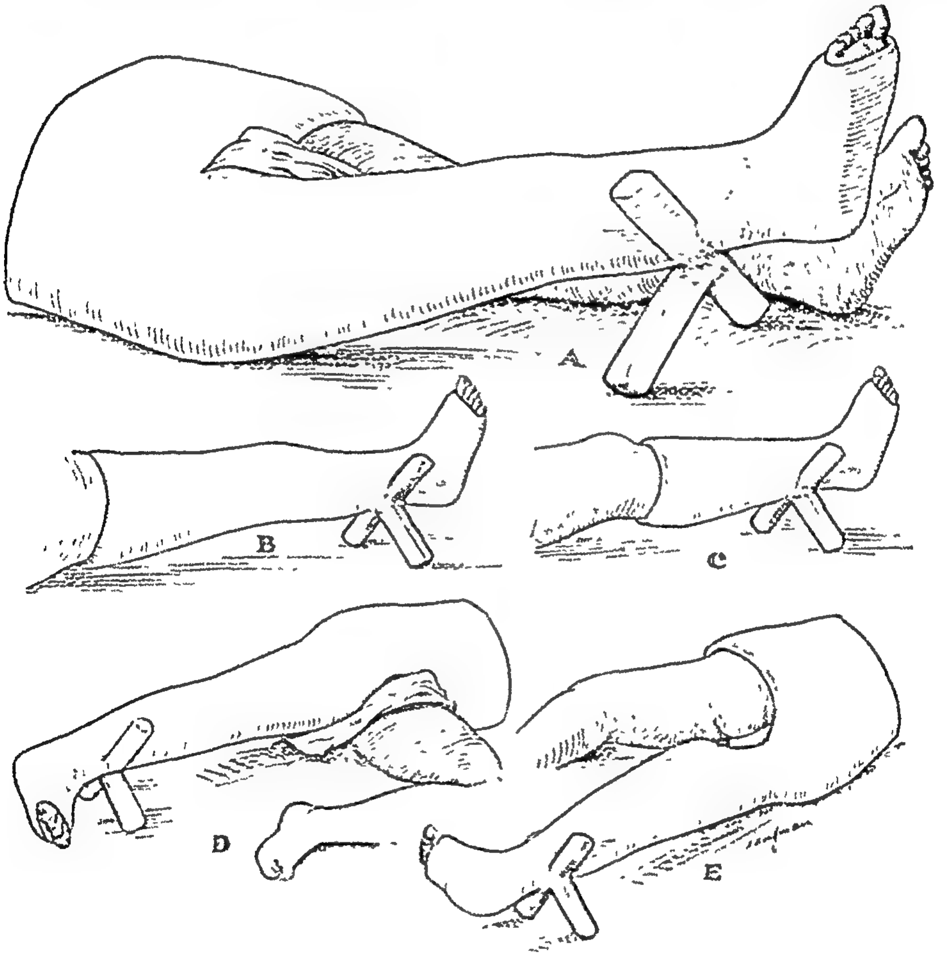


Fig. 68.—Sideman's intrinsic leg elevator. (Sideman, courtesy of Jour. Bone and Joint Surg.)

in mind that if there is an odor under the cast an ulcer is probably present and skin bacteria are growing.

Immobilization by encasement in plaster-of-Paris is an indispensable part of the treatment of many war wounds and demands good plaster technic. Good plaster technic according to Luck means the rapid application of the cast, comfort and protection to the patient, the use of a minimum of plaster, and less difficulty in transportation.

The "critical point" is that time in the setting process when the

plaster crystals interlock and give the cast rigidity and strength Movements of the cast, such as changes of alignment and molding after the "critical point" in the setting process, mean impairment of the ultimate strength of the cast The later after the "critical point" the cast is manipulated, the greater will be the damage Of the defective casts analyzed, more had been impaired by manipulation after the "critical point" than by any other single cause

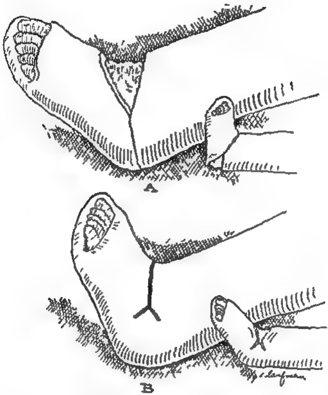


FIG 69 —Wedging of plaster-of-Paris casts on foot and ankle *A* Plastic on cast to obtain dorsiflexion in case of equinus *B* Plastic on cast to obtain plantar flexion

Detection of the "critical point" requires practice and varies with different brands of plaster but in general it is that point when the plaster is of the consistency of thick cream and begins to lose its wet glistening character When the appearance of the plaster has become dull and the cast is becoming firm, the "critical point" is passed

Lamination of casts occurs when one layer of plaster-crinoline dries before another is applied, preventing fusion of adjacent layers When fresh plaster is wrapped over a dry plaster surface, the dry surface should first be roughened by scratching it with a sharp knife This is necessary when casts have to be applied in segments, *e g* a cylinder for a shaft fracture of the tibia and fibula, then the foot portion, then the thigh portion

Most plaster-of-Paris and crinoline now available is good More unsatisfactory casts are the result of poor technic of application

than from defective plaster-of-Paris and crinoline. To overcome bad technic of application, a great excess of plaster is frequently used. The use of two or more times the required number of plaster rolls and splints is often observed.

A cast does not attain its full strength until the water within it in excess of that needed for "water of crystallization" evaporates. This

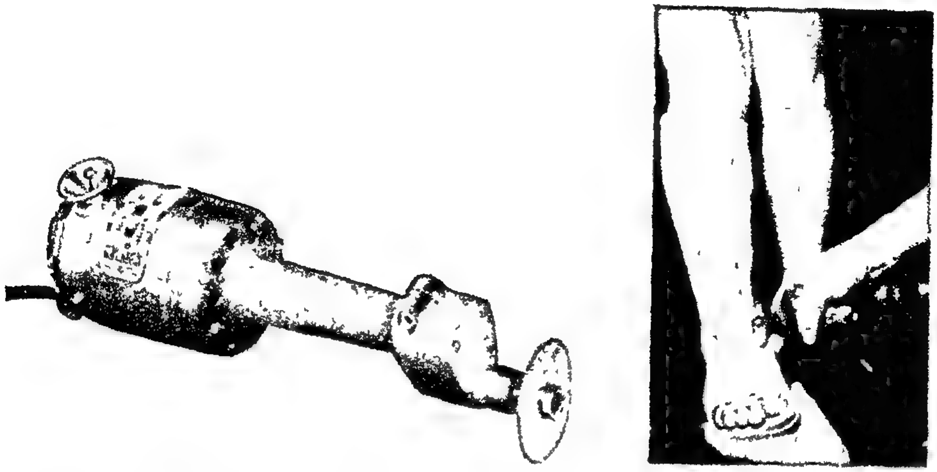


Fig. 70.—Stryker Cast Cutter—an electric cast cutter that is safe, works and saves time. This 2 inch circular saw does not rotate, but oscillates at high frequency, thus cutting the cast which is rigid, but not the padding and skin beneath, which can "give" with the oscillations. Cutting a window, bi-valving or removing a cast requires only one fourth of the usual time. (Courtesy of the Orthopedic Frame Company, Kalamazoo, Michigan.)

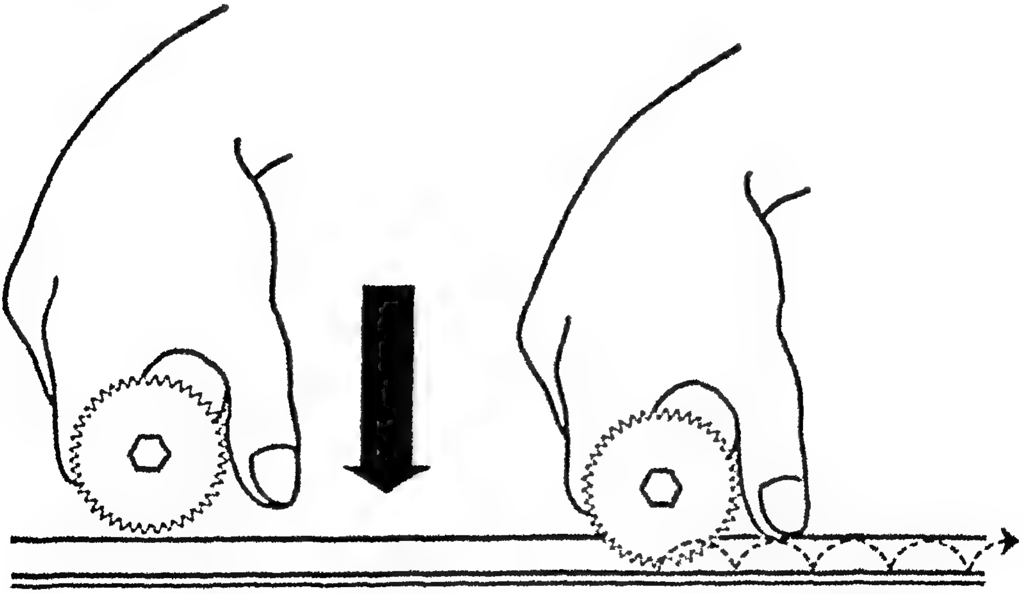


Fig. 71.—The Stryker Cast Cutter. Grasp the cast cutter as illustrated above. As pressure is put on the blade and it cuts down through the cast, the thumb serves as a depth gage, striking the cast as the saw blade reaches the padding beneath the plaster. (Courtesy of the Orthopedic Frame Company, Kalamazoo, Michigan.)

process may require several hours for small casts and several days for large ones. Arrangement for air to circulate around the cast until it dries is important. If a large wet cast is kept covered with heavy bed clothing the cast may lose its rigidity and become rubbery and useless. This is especially true in humid climates.

In the defective casts analyzed, more painful points resulted from friction beneath thickly padded casts than resulted from pressure when little or no padding was used. When no padding is used a plaster splint is best applied anteriorly and posteriorly before applying the plaster bandages. The bandages should be "laid on" never "drawn on."

With reinforcing casts that encase the ankle or knee, the reinforcement should be placed front and back and not on the sides.

The Removal of the Cast.—Splitting a Cast.—It is often desirable to split a cast immediately. This is done by means of a knife, a Stille cutter, or a saw. To protect the patient from being cut, a rope, a piece of metal, a filet of canvas, a rubber tire, or a strip of sheet-wadding of 4 thicknesses may be applied over the stockinet in the line of splitting before the plaster is applied. The cast is split as soon as the plaster has hardened. This method may be used in making models of the foot or leg. When the cast is set, it is cut off, bandaged together, and allowed to dry. Before it is cut, several transverse lines should be drawn on it with an indelible pencil so that when it is removed these lines may be matched up to make the model exactly like the cast when it was on the patient.

Stryker's reciprocating saw is a welcome addition to the orthopædic surgeon's armamentarium for cutting plaster-of-Paris casts and cutting bone grafts. It will cut a cast without injuring the skin or even cutting the padding.

When a cast is removed from a leg, one should apply an elastic compression, resilient bandage or Unna Paste Boot to prevent edema. Elevation for a few days is desirable.

A Removable Cast.—A removable or bivalve cast is made as follows: A plaster-of-Paris cast is applied as usual and worn by the patient a day or two until it is determined to be exactly correct. It is then split down the sides or down the front and back and sent to the brace-maker for the application of straps, buckles, and metal reinforcements. It may be fastened with lacings or zippers.

The Making of Plaster-of-Paris Models for Braces.—A cast is made as described in the foregoing paragraphs and then turned over to the brace-maker, who lines the inner side with talcum powder, thoroughly rubbed in, or a thin coating of green soap. Sufficient plaster-of-Paris cream to fill the mold is then poured into it. During the setting, a strip or bar of metal may be placed longitudinally so that when the

cast sets this bar will be fixed in place. Several inches of the bar should project at each end to permit easy handling of the model. The whole is placed in an oven. When thoroughly dry, it is taken from the oven and the outer shell, which was the original model, is removed. The resulting model is a positive impression of the patient's member.

Roentgenography Through a Cast.—To penetrate a cast, the strength of the rays must be increased 10 per cent and the length of the exposure 50 per cent.

Elements of Danger in the Use of Casts.—Swelling, discoloration, or a change in the temperature of the extremities indicates interference with the circulation. When the circulation is impaired the cast should be split and the edges spread. Swelling which develops through a window in the cast is called "window edema."

FIG. 72.—Mollo-Pedic shoe designed to cover swollen tender feet or those encased in bandaged or plaster casts. Note sponge rubber sole and fabric upper.

Other Types of Casts.—There are several silicon preparations on the market which are recommended as being better than plaster-of-Paris for certain purposes. The cast is made by applying repeated layers of the glue and bandage material. The resulting product is lighter than most plaster casts.

Starch bandages are sometimes used to "polish" plaster-of-Paris casts.

"Castex," a plastic material introduced by Thorndike, is sometimes used as a substitute for plaster-of-Paris. It is lighter than plaster and water-proof. Thorndike has recently introduced a new synthetic waxy material which becomes flexible and moldable upon heating and rigid upon cooling.

Another material, called "Flexosplint,"[1] has been introduced by

[1] DuPont Chemical Company has a similar product called "Lucite."

Moorhead This comes in sheets In hot water it becomes exceedingly plastic and may then be easily cut to pattern with surgical scissors It is applied to the part and, on cooling, maintains the shape into which it has been molded It is non-inflammable, translucent, radiolucent, without electric voltage, and non-irritating It dries almost immediately, and can be used over again after re-immersion in hot water

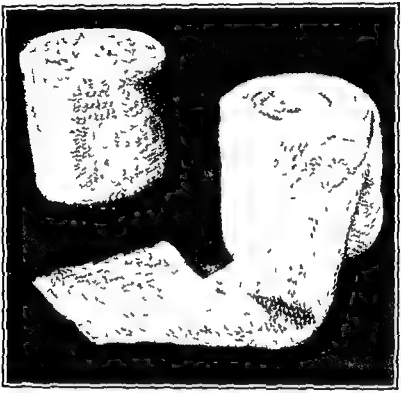


FIG 73 —The bandage is so knitted from glass and plastic fibers that it is flexible porous and elastic Its strength comes from the truss like design The bandage is made in several widths and is packaged in cellophane for ease of handling and to keep it clean (Anderson and Erickson courtesy of Tower Company)

The Technic for Making Plaster-of-Paris Models of the Feet — The foot is placed in a cake or bread pan which contains plaster-of-Paris cream made by the addition of plaster-of-Paris powder to water The pan is filled about two-fifths full of water, and the plaster dusted on slowly When the water has been saturated, the mixture is stirred until it is a fairly thick cream The foot is then placed in the pan, and after a few minutes, is removed A little salt is added to the water to make the plaster set more quickly The model obtained by this procedure is the negative This is dusted with talcum powder, and more plaster cream (without the addition of salt to the water) is poured in After several hours the outer part is removed by knocking out the original model The positive model is then shaped to the desired form, marked, and sent to the bracemaker who makes the

foot-plate. In a method of making plaster models which was devised by Whitman, thick plaster cream enclosed in muslin is made in two parts. One part is molded around one-half of the foot and the other part around the other half of the foot. The two half models thus obtained are then put together.

FIG. 71.—The bandage is easy to apply. As illustrated, the bandage is wetted by immersion in the Erickson Immersion Can. Since the bandage is elastic, it can be wrapped on under tension so as to conform to body contours. (Anderson and Erickson, courtesy of Tower Company.)

Glass Plastic Cast.—Anderson and Erickson discussed the attributes of an ideal cast, and described a new, open-mesh, waterproof, plastic cast, "cure cast," that in most respects met the requirements. The clinical effectiveness of this type of plastic cast has already been established by application to a substantial number of patients.

The bandage is a knitted, all plastic bandage which, after being wetted with setting solution, hardens into a rigid cast.

The plastic bandage previously reported had many outstanding advantages, such as resistance to water, light[illegible] weight, porosity, transparency to roentgen-ray, and cleanl[illegible] tion. There

were, however, a few drawbacks For example, considerable care was required in its application, especially to avoid applying the bandage under tension, which sometimes led to contraction of the cast The spraying on of the setting liquid required considerable time By modifying the composition of the original bandage, these faults have been eliminated, and the desirable characteristics of the bandage have not only been retained but even bettered

The liquid used at present is a combination of acetone, methyl salicylate, and a group of hydrocarbons The accurate formulation of this blend defines and regulates its action so that the glass and plastic filaments will fuse together without the cellulose acetate being appreciably dissolved or softened

The technic of applying the glass plastic bandage resembles that for a plaster cast

Padding may be used but is not required The bandage may be applied directly to the skin which has been dusted with talcum powder

Stockinet is used by many

Thin strips of felt can be used to assist in wedging, bivalving or removal

The bandage can be sterilized by autoclave The bandage is wetted by immersion in the setting fluid The bandage is immediately withdrawn from the liquid and with some tension it is wrapped in place, after cast has been completed, an ordinary elastic cotton bandage is wrapped over the entire cast The cast is then shaped, smoothed down, and circularly rubbed with the palm for a few minutes, after which the cotton bandage is removed Setting can be hastened by using a small hair drier

The glass plastic bandage can be used for all types of immobilization Since the material is waterproof, the patient can bathe, and the cast can be cleansed with soap and water In the treatment of poliomyelitis, arthritis, hand and other infections, and most traumatic conditions, hot packs and hydrotherapy can be carried on without disturbing immobilization

Since the cast components do not absorb liquids or odors, involuntaries of senile or infant patients do not harm the cast and can be removed by washing

The elastic bandage is knitted with an open mesh and is so processed that it can be safely applied under tension to conform to every contour It is as suitable for a little finger cast as for a large spica cast

It is ideal for immobilization of foot injuries and facilitates early return to work because the cast will not soften from absorption of liquids and can be readily cleansed of dirt

The cast can be cut with an ordinary cast cutter, or, by applying

foot-plate. In a method of making plaster models which was devised by Whitman, thick plaster cream enclosed in muslin is made in two parts. One part is molded around one-half of the foot and the other part around the other half of the foot. The two half models thus obtained are then put together.

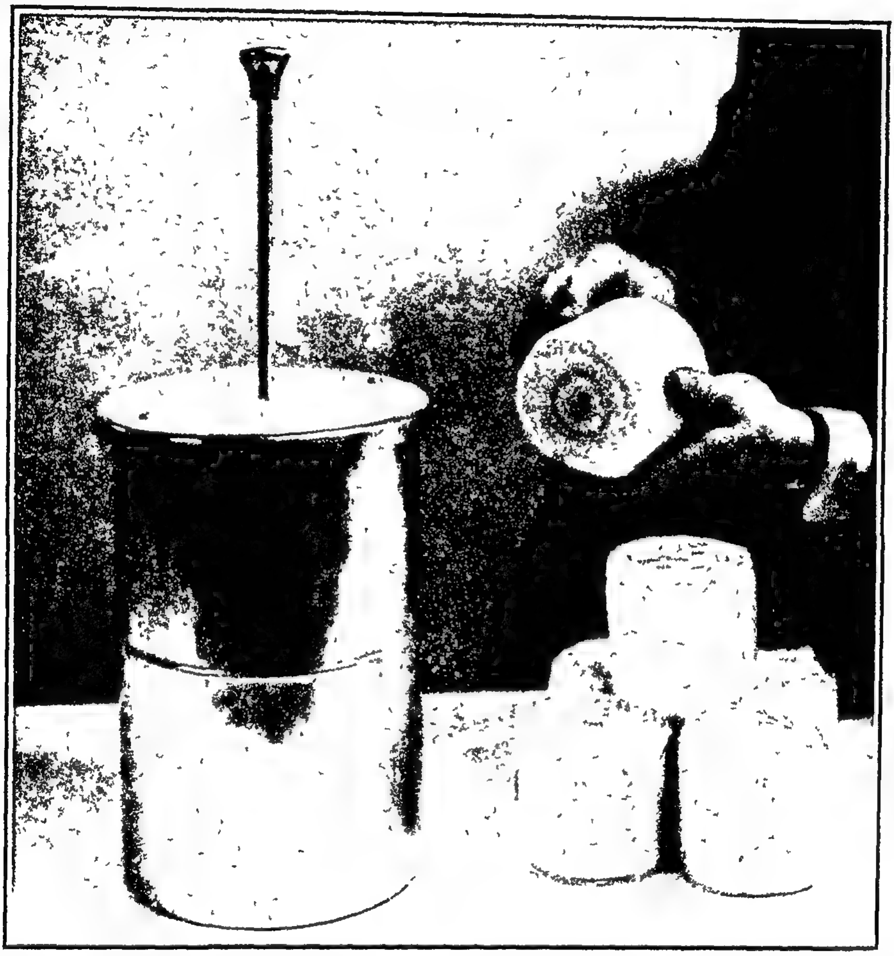


Fig. 74.—The bandage is easy to apply. As illustrated, the bandage is wetted by immersion in the Erickson Immersion Can Since the bandage is elastic, it can be wrapped on under tension so as to conform to body contours. (Anderson and Erickson, courtesy of Tower Company.)

Glass Plastic Cast.—Anderson and Erickson discussed the attributes of an ideal cast, and described a new, open-mesh, waterproof, plastic cast, "cure cast," that in most respects met the requirements. The clinical effectiveness of this type of plastic cast has already been established by application to a substantial number of patients.

The bandage is a knitted, all plastic bandage which, after being wetted with setting solution, hardens into a rigid cast.

The plastic bandage previously reported had many outstanding advantages, such as resistance to water, lightness of weight, porosity, transparency to roentgen-ray, and cleanliness in application. There

were, however, a few drawbacks For example, considerable care was required in its application, especially to avoid applying the bandage under tension, which sometimes led to contraction of the cast The spraying on of the setting liquid required considerable time By modifying the composition of the original bandage, these faults have been eliminated, and the desirable characteristics of the bandage have not only been retained but even bettered

The liquid used at present is a combination of acetone, methyl salicylate, and a group of hydrocarbons The accurate formulation of this blend defines and regulates its action so that the glass and plastic filaments will fuse together without the cellulose acetate being appreciably dissolved or softened

The technic of applying the glass plastic bandage resembles that for a plaster cast

Padding may be used but is not required The bandage may be applied directly to the skin which has been dusted with talcum powder

Stockinet is used by many

Thin strips of felt can be used to assist in wedging, bivalving or removal

The bandage can be sterilized by autoclave The bandage is wetted by immersion in the setting fluid The bandage is immediately withdrawn from the liquid and with some tension it is wrapped in place, after cast has been completed, an ordinary elastic cotton bandage is wrapped over the entire cast The cast is then shaped, smoothed down, and circularly rubbed with the palm for a few minutes, after which the cotton bandage is removed Setting can be hastened by using a small hair drier

The glass plastic bandage can be used for all types of immobilization Since the material is waterproof, the patient can bathe, and the cast can be cleansed with soap and water In the treatment of poliomyelitis, arthritis, hand and other infections, and most traumatic conditions, hot packs and hydrotherapy can be carried on without disturbing immobilization

Since the cast components do not absorb liquids or odors involuntaries of senile or infant patients do not harm the cast and can be removed by washing

The elastic bandage is knitted with an open mesh and is so processed that it can be safely applied under tension to conform to every contour It is as suitable for a little finger cast as for a large spica cast

It is ideal for immobilization of foot injuries and facilitates early return to work because the cast will not soften from absorption of liquids and can be readily cleansed of dirt

The cast can be cut with an ordinary cast cutter, or, by applying

the setting fluid or a softening cream, it can be cut with bandage scissors or Stryker's electric saw.

The cast is cool to wear, its porous structure admits light and air, and even when the cast is wet it does not block roentgen-ray penetration. It can be used in the tropics because it does not absorb moisture and is not affected by humidity, molds, or fungi.

The bandage can be sterilized in the autoclave. The preliminary clinical work in these fields shows promise and points to it as a useful addition to the armamentarium of the surgeon.

OPERATIVE TREATMENT

Historical Review of Surgery of the Foot and Ankle.—Bone operations designed to correct deformities of the foot and ankle are distinct from the general rule of operations performed elsewhere upon the skeleton. Bick states that in 1608 Hildanus removed a fractured talus. Broca, in 1852, and Lund, in 1872, advocated removal of the astragalus for local destructive disease. In 1857, Cook suggested extirpation of the astragalus, scaphoid, cuneiform, and cuboid for the same reason. In 1857, Solly removed the cuboid to correct a club-foot. In 1878, Albert performed a stabilizing operation for the relief of paralytic deformities of the foot. In the same year, Golding-Bird performed a similar operation for severe flat-foot deformity. In 1884, Ogston performed a talonavicular arthrodesis for flat-foot.

In 1901, Royal Whitman performed the first astragalectomy and backward displacement of the foot for paralytic calcaneus. In 1908, Jones described a fusion operation for calcaneo-cavus. Goldthwait, also in 1908, fused the ankle joint in cases of flail feet. In 1911, Lorthoir reported 8 cases in which the astragalus was removed, denuded of cartilage on all sides, and replaced. In 1913, G. G. Davis described a fusion operation.

In addition to these procedures, Jones, Perthes, Putti, Ryerson, Dunn, Hibbs, Steindler, Campbell, Zadek, Gill, Lambrinudi, and others have proposed modifications of the surgical correction of deformities of the foot. Hoke's arthrodesis is one of the most important contributions. (Fig. 304). Mayer formerly corrected certain deformities entirely by tendon transplantation, but recently has added to his original procedure a modification of Hoke's operation. Gallie, Whitman, and others have likewise devised muscle-tendon operations. In cases of severe valgus deformities Gleich and Lord sawed the calcaneus in an oblique direction and shifted the posterior fragment forward.

H. O. Thomas advocated immediate forcible correction of the club-foot followed by the application of a retention splint devised to maintain an overcorrected position. He constructed an osteoclast of special

design, the "Thomas wrench" Grattan, Bradford, Lorenz, and Putti designed osteoclasts Koenig and Lorenz "broke" the deformity over the apex of a padded pyramid According to Brockman, a plaster bandage was first used to splint a corrected club-foot in 1836, by Guerin Achillo-tenotomy was introduced by Stromeyer Agustoni and Morestin attempted to improve the position of the foot by removing the astragalus Championniere removed several bones of the tarsus in addition to the astragalus Severe operations cause mutilation of the internal architecture of the foot and invariably leave the foot more or less painful Kite corrects the deformity by slow conservative manipulations without anesthesia Each correction is followed by the application of plaster to hold the new position (Fig 77) After maximum correction has been obtained, a period of observation is allowed If a tendency toward recurrence is noted, the foot is fused surgically

Operative treatment includes aspiration and injection of joints, manipulation under anesthesia, and open operations In all operations upon bones and joints of the foot and ankle the incision and approach to the area to be operated upon should be such that impairment of the circulation will be minimal

Excellent orthopædic results can be invalidated by improper, inefficient, or inadequate preoperative or postoperative nursing care

Aspiration —In aspirating the ankle joint great care should be taken to avoid blood-vessels, nerves, and bones Aspiration must be performed under the strictest aseptic precautions

Injection —Injection may be performed in cases of arthritis The solutions most often injected are normal salt solution, formalin and glycerin, formalin in olive oil, Morris's synthetic synovial fluid, methylene blue, gentian violet, ether, Lugol's solution, Pregl's solution and novocain

Arthrotomy —Arthrotomy of the ankle joint is performed for diagnostic purposes as in the biopsy operation for the removal of synovial membrane, cartilage, or bone It is performed therapeutically in cases of loose bodies in the joint, fractures into the joint, synovectomy, and arthroplasty

Resection —Resection of the ankle joint is performed most commonly for tuberculosis, osteomyelitis, syphilis, and the residual effects of poliomyelitis

CHAPTER V

CONGENITAL DEFECTS AND DEFORMITIES

THE most common and important congenital defect or deformity of the foot and ankle is club-foot.

CONGENITAL CLUB-FOOT

Club-foot, or talipes, may be congenital or acquired. There are four simple and four compound varieties:

SIMPLE TYPES	Talipes	equinus	Talipes	varus
		calcaneus		valgus
COMPOUND TYPES	Talipes	equino	varus	
			valgus	
		calcaneo	varus	
			valgus	

Heredity is a factor in the production of club-foot (equinovarus). About one-third of the cases occur in the first-born child. The condition is most frequent in children borne of multiple pregnancies. Unilateral symmetrical congenital equinovarus in twins has been reported. Some club-feet are said to be the result of an abnormal position *in utero*. Bohn claims that all the clinical manifestations substantiate the conclusion that congenital club-foot is the result of an intra-uterine maldevelopment or an arrest of development due to an endogenous disturbance of the embryo. Brockman believes that the cause lies in a congenital subluxation of the astragalo-scaphoid joint, and that relapse is due to failure to reduce this dislocation.

The diagnosis includes determination of the type of the club-foot and whether or not it is congenital. The prognosis depends upon the age of the patient, the type of the club-foot, the degree of deformity, the degree of rigidity, the treatment, and the duration of observation. The long narrow foot is much more amenable to treatment than the short, chubby foot. Manipulation should be begun at the earliest possible moment. I once removed a premature infant from an incubator long enough to apply a plaster-of-Paris cast. At the end of five days, more correction had been obtained than could have been accomplished in five weeks if treatment had been delayed.

I suggest describing the degree of club-foot by means of a scale based upon the external conformation of the foot and the relation of the bones as shown by the roentgen-ray

The treatment includes manipulation with or without anesthesia, the use of retention apparatus, and, in resistant cases, operations such as tenotomy, tendon transplantations, fasciotomy, capsulotomy, osteotomy, astragalectomy, and arthrodesis The test of cure is the position of the foot in walking A cured club-foot will not relapse

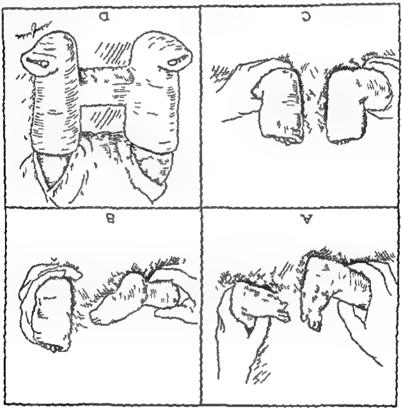


Fig 75 —Lewin's cross bar cast for congenital club-foot *A* club foot in a child eleven days old *B* Left foot corrected by manipulation and placed in a plaster-of Paris cast *C*, Both feet corrected and in casts *D* Cross bar casts made of tongue depressors maintaining outward rotation of the legs (Drawn from photos by Lewin courtesy of Jour Am Med Assn)

TALIPES EQUINOVARUS

About 75 per cent of congenital club-feet are of the equinovarus type (Fig 75*A*) This type occurs once in 1000 births Sixty-five per cent of the cases occur in males, 57 per cent are unilateral Anatomically, the deformity presents three elements plantar flexion, adduction, and inversion The chief structures holding the foot in inversion are the contracted internal lateral (deltoid) ligament, the inferior calcaneo-scaphoid ligament, the posterior tibial tendon, the plantar fascia, and the Achilles tendon The Achilles tendon not only resists dorsiflexion of the foot but acts as an invertor since it is deflected

toward the medial side. The scaphoid and the cuboid approach the mid-line. Secondary adaptive distortion occurs in the astragalus and other tarsal bones. In addition, there is often an imbalance of the internal and external rotator muscles of the thigh and leg. Bow-legs frequently accompany club-feet.

The chief factors responsible for incomplete cures, recurrences, and failures are:

1. Delay in starting treatment. Improvement is proportionate to the flexibility of the foot.
2. Failure to overcorrect every element of the deformity.
3. Failure of the patient, parent, or surgeon to persist in the treatment. Maintenance of the foot in the corrected position with weight-bearing must be continued until the patient is able to put his foot voluntarily in a position of overcorrection. The period of fixation should be followed by a long course of treatment with local heat, massage of the leg muscles, and passive and active movements.

Non-operative Methods for the Correction of Equinovarus in Infants.—*Lewin's Technic.*—Even when the patient is only a few hours old, I employ plaster-of-Paris to retain the feet in the corrected or overcorrected position which has been obtained by gentle manipulation. My technic is shown in Figure 75.

Following the routine application of casts, one applies a crossbar of plaster with a foundation consisting of two wooden tongue depressors or two round pencil-shaped rods of wood cut to the required length, one over and the other under the completed casts at a point about 1 inch above the internal malleolus.

A few turns of plaster bandage are then applied, making a solid but very light crossbar connection. This may be used to hold the legs in any position of external rotation desired. It is noteworthy that after treatment and correction of club-foot there often remains an inward rotation of the lower legs or entire lower extremities which causes disability and a visible deformity. This method will eliminate a considerable portion of this deformity and will undoubtedly reduce to a minimum the number of patients requiring extensive casts, braces or osteotomies.

The following methods prevent slipping of the cast: (1) fixation of the stockinet to the skin with Heussner's glue (alcohol 50 cc.; benzine 25 cc.; resin 50 gm.; Venice turpentine 5 gm.); (2) the application of adhesive tape to the skin, the ends being left long, turned back and incorporated in the cast; and (3) extension of the cast above the flexed knee.

Rush and Rush recommend a molded plaster splint instead of a circular cast to maintain the corrected position. This splint is from 8 to 10 layers thick, from 16 to 20 inches long, and from 1½ to 2½ inches wide.

Kite divides the treatment into (1) correction of the varus deformity, (2) correction of the equinus deformity, (3) retention in an overcorrected position, and (4) follow-up treatment He wedges the casts first in abduction and later in dorsiflexion (Fig 77) He cautions against dorsiflexion until the astragalus and os calcis are unlocked as shown in anteroposterior roentgenograms (Fig 76)

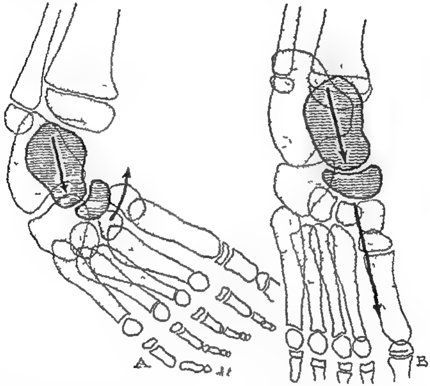


FIG 76 —Tracings made from roentgenograms of the right foot of a seven year-old girl, before and after correction of club foot deformity by plaster casts and wedgings The roentgenogram made before treatment shows that the weight thrust of the body coming down the tibia is transmitted forward through the astragalus strikes obliquely on the side of the navicular and pushes the forefoot around in adduction When the adduction deformity of the forefoot has been completely corrected this weight thrust is transmitted straight forward from the astragalus through the navicular to the toes as shown in the tracing of the roentgenogram made after correction of the forefoot adduction If the wedging of the forefoot in abduction is stopped before the navicular is directly in front of the head of the astragalus the deformity will recur when weight-bearing is permitted because the weight thrust will fall obliquely on the navicular (Redrawn from J H Kite courtesy of Jour Bone and Joint Surg)

The Denis-Browne Club-foot Splint —The principle of the Denis-Browne splint for the correction of club-feet is to strap the feet to the splint, which has a connecting cross bar, and then let the infant correct its deformity by his own kicking This method minimizes manipulations, plaster casts, tenotomies and anesthetics It saves time at the clinic The success of the method varies inversely with the age of the child An upper limit of three years is suggested by Thomson

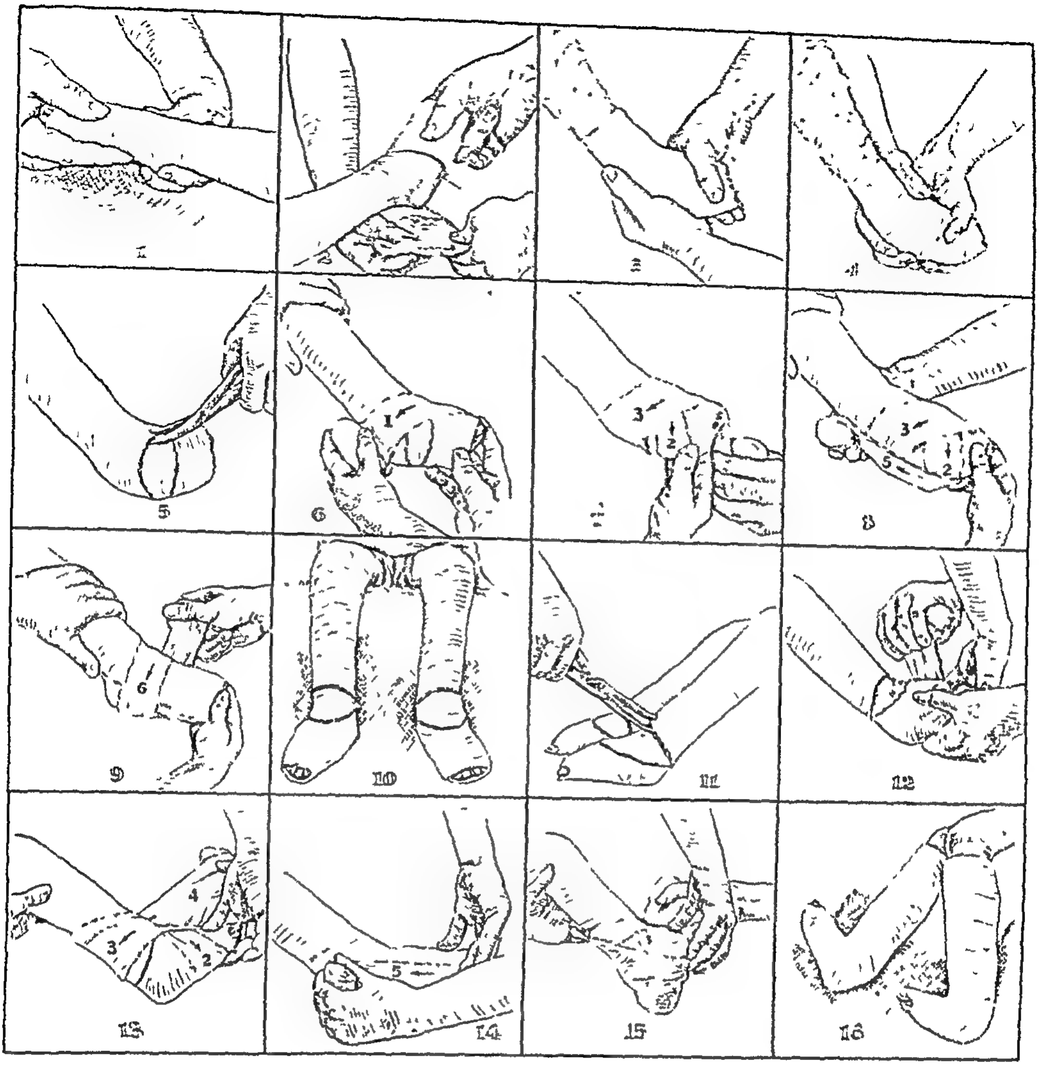


FIG 77

1 The foot is held by the surgeon's index finger under the medial side of the great toe, giving good control of the foot and allowing the assistant ample room to apply the cast

2. Extra pads of sheet wadding are applied over the medial side of the great toe, lateral side of the foot, and over the heel and knee

3 The first step in molding the foot after the plaster has been applied The left hand grasps the heel on the lateral side, pulling the posterior end of the os calcis outward, and with the thenar eminence of the palm, pressure is made inward and upward on the anterior end of the os calcis and cuboid. The plaster over the toes is flattened by pressure between the thumb and fingers, while at the same time the right hand carries the toes outward in abduction by pressure of the crotch of the thumb against the head of the first metatarsal

4 The second step. The final molding is best done from the opposite side of the table The right hand grasps the heel and the left hand the toes and with the fingers pressing upward and inward on the calcaneo-cuboid region, the heel and the toes are points of counterpressure and are carried outward.

5 Wedging in abduction A wedge-shaped portion of plaster has been removed from the side of the foot and the cut edges of the plaster are being turned out to prevent pressure.

6 Wedging in abduction. A figure-of-eight turn is made with a plaster bandage starting on the medial side, so that the forefoot will be drawn outward.

7. Wedging in abduction One and a half figure-of-eight turns are made and the bandage carried around behind the heel and brought forward along the medial border of the foot and around under the toes.

8. Wedging in abduction. The bandage is carried back along the outer border of the foot and pulled tight so as to draw the forefoot out in abduction.

9 Wedging in abduction The remainder of the bandage is used to reënforce the cast where the edge has been removed

10 Wedging in dorsal flexion. A wedge-shaped portion of plaster is removed from the anterior surface of the ankle, cutting the cast at the level of the malleoli, leaving the plaster on the foot like a low quarter shoe

11. Turning out the edges to prevent pressure. When the foot is dorsally flexed it comes up as a whole without breaking in the transverse tarsal joint.

12 Wedging in dorsal flexion The two portions of the cast are closed with a plaster bandage. Beginning the figure-of-eight turn

13 and 14. Wedging in dorsal flexion One and a half figure-of-eight turns are applied, carrying the plaster higher up on the leg so as to draw the foot up in dorsal flexion. A lateral turn is made by bringing the bandage around on the medial side of the foot and under the toes and up on the lateral side, which holds the foot in dorsal flexion

15. The remainder of the bandage is used to reënforce the area from which the wedge was removed

16. The feet are held in dorsal flexion eight to twelve weeks. Last cast extends only to the knee. No evidence of "rocker bottom"

(Redrawn from Kite, South. Med Jour.

The splints are available in three sizes, the largest size being used for old recurrent cases

There is an upright projection on the outer side which reaches the upper border of the malleolus An important feature is the posterior narrow projection for anchoring the adhesive and keeping the heel in place The splint is covered with sponge rubber On the under side is a bolt, with a circular metal washer at its base which contains a series of holes A pin in a cross bar fits into the desired hole and makes the position secure and easily recorded from week to week At each visit the foot is restrapped and the position of the foot piece on the cross bar is adjusted to increase the degree of correction

1 Paint foot with compound tincture of benzoin
2 Apply foot-plate to sole of foot and hold firmly
3 Apply 6 to 8 strips of 1-inch adhesive plaster
4 Attach cross bar
   (*a*) Place a narrow strip of felt over dorsum of ankle joint for protection
   (*b*) Place a narrow strip of felt over achilles tendon

The strapping should imitate that used for a sprained ankle

Remarks —Thomson uses a reversed Denis-Browne splint *i e*, the cross iron is adjusted so that the convexity is toward the groin

Masking tape may be used instead of adhesive tape

Change the apparatus every one to four weeks

A piece of sponge rubber should be placed in the shoes

J W White glues the soles of the feet together with compound tincture of benzoin or other adherent material and binds the feet together with a resilient bandage for three or four months

There has been some discussion as to when to treat congenital foot defects—especially club-feet I have discussed this matter personally with Drs Hoke and Kite Their idea was that they would prefer to see the baby when six weeks old

I would prefer to see him when he is six minutes old

The almost completely corrected club-foot is a condition to be carefully avoided The neglected mild club-foot deserves serious attention The "relapsed" club-foot was never a "cured" club-foot

The treatment of congenital club-feet requires the cooperation of the family physician, the parents and the orthopædic surgeon, and in some cases, according to Kite some philanthropic organization

The deformity in talipes equino-varus consists of three component parts The first is the "forefoot adduction" The second is "inversion"

and the third is "equinus" deformity. This last can be divided into "forefoot equinus" and "ankle equinus." Each of these deformities must be corrected in the order mentioned. If an attempt is made to correct the equinus deformity before completely correcting the forefoot adduction and inversion deformities, the deformity is sure to recur when the foot is released from plaster, no matter how long it is kept in plaster.

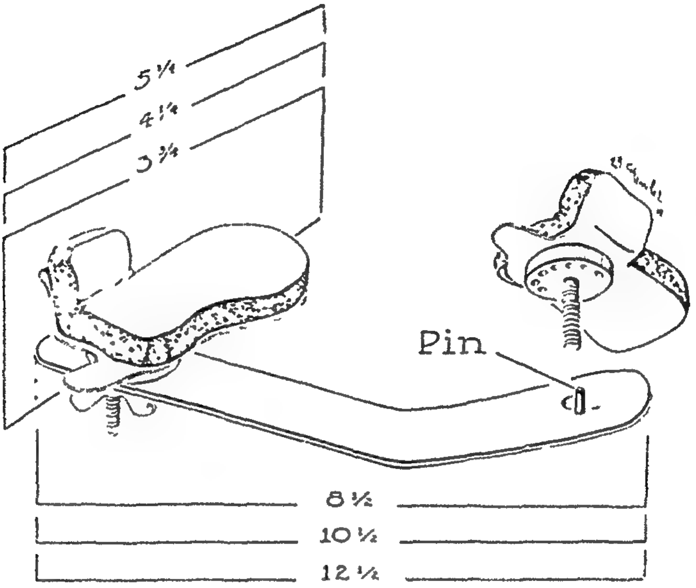


FIG. 78.—Thomson modification of Denis-Browne splint for club-feet. (Thomson, courtesy of Jour Bone and Joint Surg.)

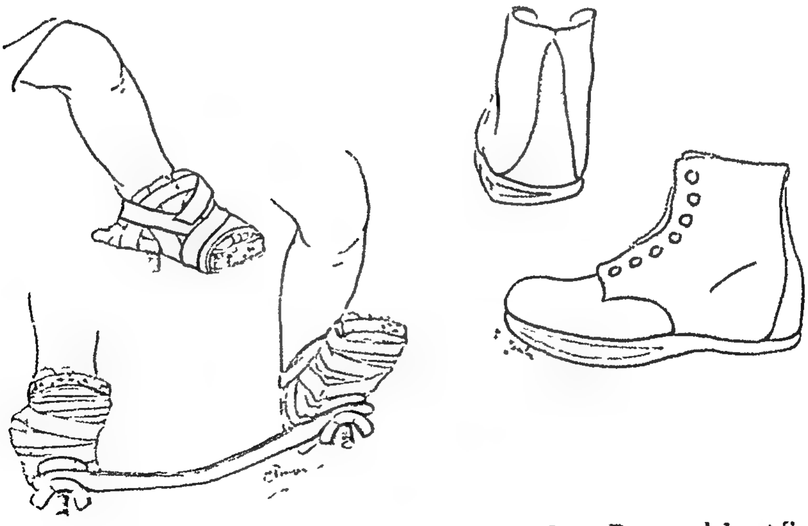


FIG. 79.—Club-foot boots. (Thomson, courtesy of Jour. Bone and Joint Surg.)

One of the reasons for recurrences is the failure to correct all of the forefoot adduction and inversion deformities before beginning dorsiflexion. It is difficult to tell clinically when these deformities have been

corrected. Kite published a method for determining this accurately by roentgen-ray.

Kite stresses the importance of beginning treatment early, and to ask that the clubfooted children not be treated before being referred, and that the treatment used be "non-operative." During the last fifteen years Kite has personally treated over four hundred clubfooted patients. Ninety per cent have been successfully corrected by this method. The ten per cent requiring operative treatment were those who had had previous treatment or who were not referred for treatment until they were well advanced in years, proving that *poor* treatment is worse than no treatment.

Pre-Walker Club Foot Shoe.—This club foot shoe may be worn from infancy until the child can stand or walk alone.

This "pre-walker" has a decided outward flare to the fore-part of the shoe, and contains a flat steel plate extending from heel to toe, keeping the shoe flat and not allowing it to be warped or distorted while in use. (Fig. 83.)

The "pre-walker" club foot shoe can be worn while the child is in bed. Its function is to keep the foot in the exact position that the physician has obtained. The "pre-walker" club foot shoe has a strap that goes over the instep, which holds the heel down into place, giving extra assurance of holding the foot in the exact position desired.

As the infant progresses to the point of walking or standing alone and further corrections are required, the regulation club foot shoe can be used.

Mis-mating and single shoe service, already maintained on brace, club foot, and surgical shoes is extended to include the pre-walker club foot shoe. It will simplify handling those cases that have hitherto presented a real problem. You can order one single pre-walker club foot shoe or mis-mated sizes in either or both without extra mating charge.

Brockman Operation.—Under an Esmarch bandage a short incision is made over the outer side of the os calcis and all the plantar muscles and fascia are freed from the plantar surface of the os calcis. Another incision is then made through the skin and fascia along the inner border of the foot. The tibialis posticus tendon and the vessels will be recognized and found in a more forward position, passing straight down instead of in the usual curved direction, entering the sole of the foot at a right angle. On the posterior side of the tendon and vessels the incision is carried to the os calcis. The remaining plantar structures on the inner side with the origin of the abductor hallucis are freed with a small chisel. It is well to carry this stripping out on the surface of the os calcis to the calcaneo-cuboid articulation and up to the subastragalar joint.

The vessels and tendons are retracted and the incision is carried to the scaphoid and internal cuneiform bones. If necessary, the sheath of the tibialis posticus can be opened and the tendon divided. To expose the scaphoid and sustentaculum, the insertion of the tibial tendon is freed from the scaphoid and reflected with all the structures from the internal inferior surface of the tarsals. The proximity of the scaphoid to the internal malleolus can be determined by moving the forefoot. All of the ligaments on the internal and inferior surface are divided, and if the scaphoid and the internal malleolus are not widely separated, the ligaments on the superior surface of the scapho-astragalar joint are divided in addition.

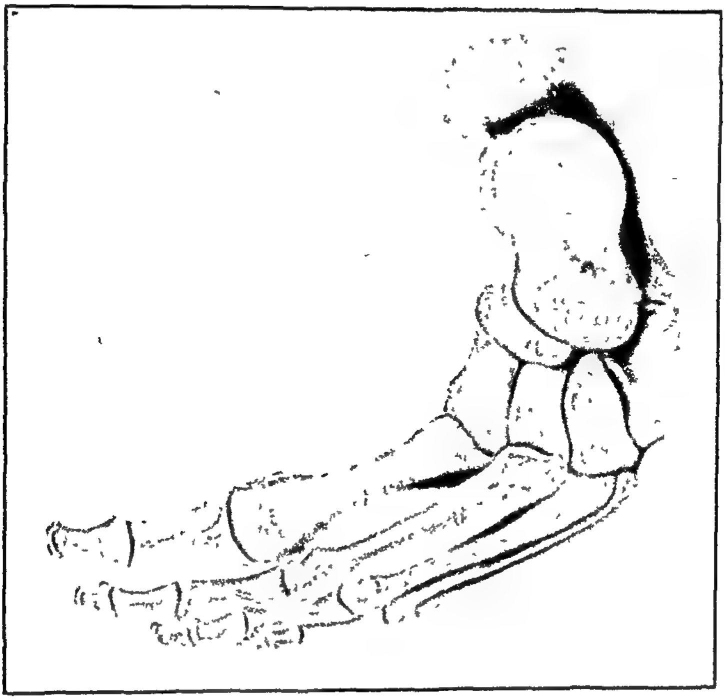


FIG. 80—Bones of the foot in extreme talipes equinovarus. (Courtesy of Dr. Michael Hoke)

The foot is then manipulated and the forefoot everted. If it is not loosely held in a fully corrected position, the dissection is carried forward on the plantar surface, the attachment of the tibialis posticus being freed from the other tarsal bones and all resisting ligaments on the superior internal surface of the scaphocuneiform joint also freed. In one case it was necessary to sever the ligaments between the internal cuneiform and the first metatarsal.

The dissection must be continued until the scaphoid is fully replaced in front of the astragalus, the anterior part of the os calcis moves outward from beneath the astragalus, a space exists between the sustentaculum and the scaphoid, and the heel is really everted.

Trethowan performs multiple capsulotomies along the inner border of the foot The surgeon should not be in a hurry to cut the Achilles tendon, and should not dorsiflex the foot until the relations of the astragalus, os calcis, scaphoid, and cuboid are corrected

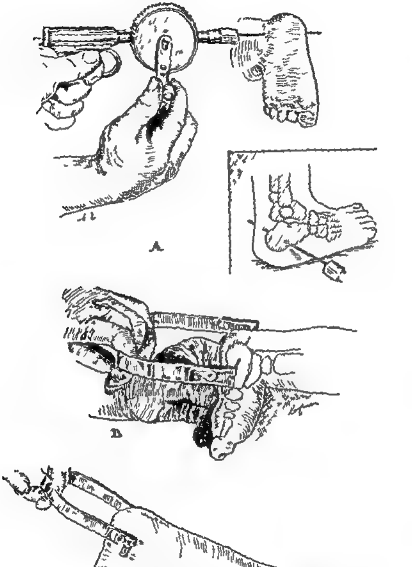


FIG 81 —*A* Kirschner wire is being introduced through the posterior portion of the os calcis *B* Downward traction is being made on the Kirschner wire through the tension device attached to it At the same time firm pressure is being made against the calcaneo-cuboid joint *C* Plaster has been applied while the foot is held in corrected position The tension device is still in place (Mayer courtesy of Jour Bone and Joint Surg)

Ober's operation is performed in the cases of children over two years of age. A long curved incision is first made over the medial aspect of the ankle joint. A second incision exposes the ankle joint. The deep fascia and periosteum are dissected from the bone in such a way that the flap includes the portion of the deltoid ligament which is attached to the internal malleolus and the internal aspect of the astragalus. On retraction of the flap, the tip of the sustentaculum appears. From this, the ligaments and periosteum are removed, the dissection being carried well down on the internal surface of the calcaneus so that the whole attachment of the ligaments is removed from it subperiosteally. In older children, Ober lengthens the posterior tibial tendon.

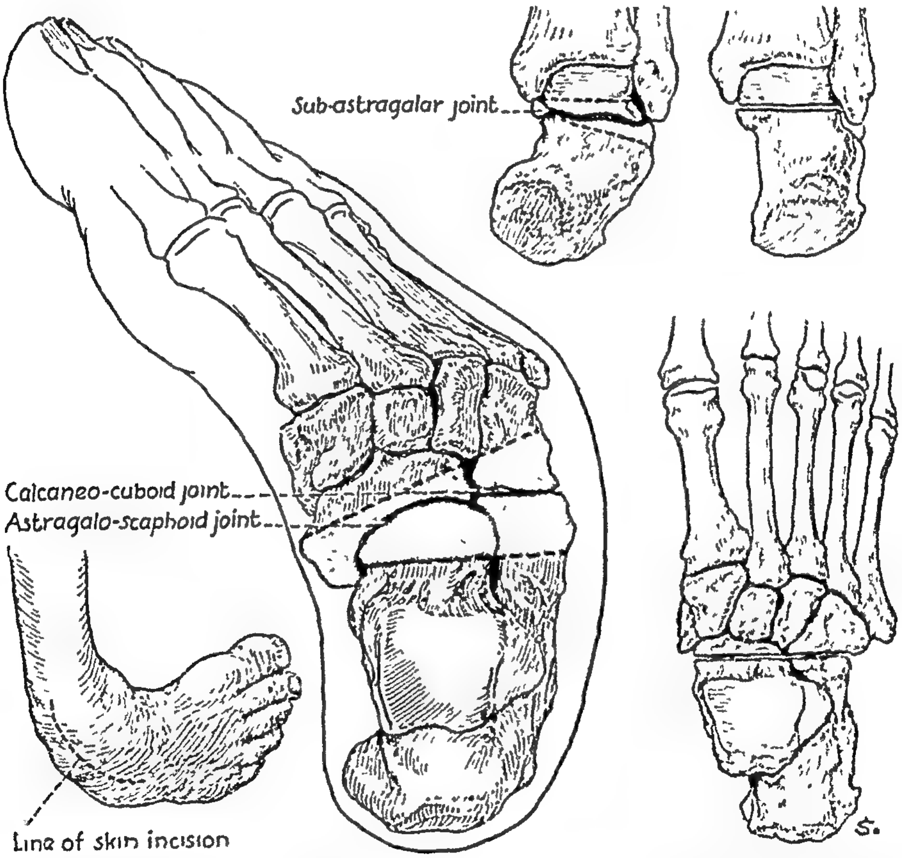


FIG. 82.—Operation for neglected equinovarus deformity Shaded areas indicate amount of bone removed from mid-tarsal region and subastragalar joint in moderate, fixed deformity. In severe deformity, the mid-tarsal wedge may include even a portion of the cuneiform bones and a larger portion of the astragalus and os calcis. (Campbell's Operative Orthopedics, courtesy of the C. V. Mosby Company.)

Next, the astragalonavicular ligament is removed subperiosteally from the scaphoid, and the superior surface of the astragalus is cleared of the anterior tarsal ligament if it is adherent. The plantar fascia is divided subcutaneously. The adduction is overcorrected by manipulation over a wedge. The inversion and plantar flexion are then fore-

ibly attached until moderate overcorrection has been secured Next, the Achilles tendon is divided subcutaneously and the manipulation is continued until the foot can be held in overcorrection with a finger The periosteal-ligamentous flap is sutured with an interrupted chromic catgut stitch to the anterior portion of the deltoid ligament in such a way as to leave a good margin of its tip in contact with the lower end of the malleolus

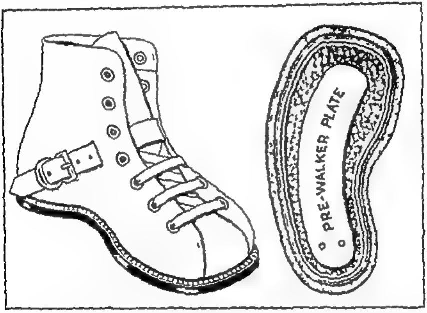


FIG 63—The "pre walker" club foot shoe carries a decided outward flare to the forepart and strap and buckle as shown by illustration Bottom construction includes a flat steel plate extending from heel to toe as illustrated Single sole flat bottom no heel (Courtesy of I Sabel Philadelphia)

In the operation performed by Heyman, the deltoid ligament is severed from the internal malleolus and detached subperiosteally from the astragalus os calcis, and scaphoid The astragalo-scaphoid capsule and the inferior calcaneo-scaphoid ligament are then divided If the tibialis posticus tendon resists eversion, it is lengthened If abduction of the forefoot is resisted, the adductor hallucis is cut through near its attachment to the os calcis The foot is then forcibly manipulated to the maximum degree The Achilles tendon is lengthened If overcorrection still cannot be obtained, a posterior capsulotomy of the ankle joint is done

Hoke's operation features temporary removal of the head of the astragalus by an osteotomy of its neck This affords full exposure of the resistant ligaments and facilitates manipulation for correction of the varus position of the os calcis The resistant ligaments may be freed from the tubercle of the scaphoid or completely excised The scaphoid may then be rotated outward The head is replaced to the

inner side of its former position where, by filling out the depression on the inner side of the foot, it prevents adduction of the forefoot like a bony block. Before the head is replaced the varus position of the os calcis must be corrected. If the cuboid blocks complete abduction of the forefoot, the removal of a bony wedge from the calcaneocuboid joint or directly through the cuboid is advisable. Care should be taken to avoid injuring the cartilage of the subastragalar and astragaloscaphoid joints.

Kite's operation consists in removing a portion of the cuboid and the os calcis, cutting off the head and neck of the astragalus, replacing a small part of the astragalus, and then performing a subastragalar arthrodesis. In the cases of children under eight years of age, Kite prefers to postpone this operation.

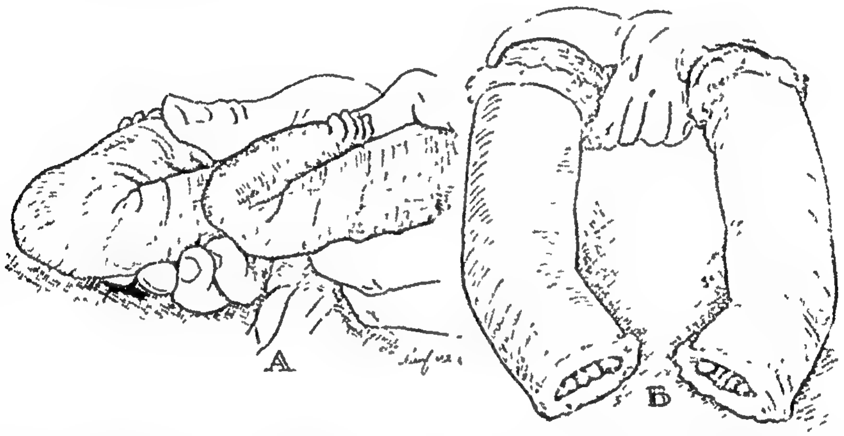


Fig. 84.—Congenital talipes calcaneus. *A*, At birth. *B*, In corrective plaster casts applied within six hours after birth. (Drawn from photos.)

Decancellation of the Os Calcis, Astragalus, and Cuboid.—In the method recommended by Curtis, a small puncture wound is made in the neck of the astragalus, the anterior portion of the os calcis, and the cuboid, and the cancellous portions of these bones are removed with successively larger curets. From the cuboid, all of the cancellous portions are removed, but from the os calcis and astragalus only the anterior portions. The foot is then forcibly overcorrected by manipulation with a Thomas wrench.

Mayer's method of overcoming severe equinus deformity in cases of congenital club-foot and cases of paralytic equinus consists in driving through the posterior part of the os calcis, a nail or wire by mea which the os calcis can be firmly grasped, and performing a p capsulotomy. The nail is included in the plaster-of-Paris. (Fi

In many severe cases, manipulation followed by l n the tendon Achillis, plus a capsulotomy of the of the ankle joint, will correct the deformity.

older children, I have found the following procedure successful (1) wrenching, (2) plantar fasciotomy, (3) lengthening of the tibialis posticus tendon, (4) lengthening of the Achilles tendon, and (5) posterior capsulotomy of the ankle and astragalo-calcaneal joints

Accidents and Unfavorable Results—During manipulation there is danger of injuring the epiphysis of the lateral malleolus, of pulling off the attachment of the Achilles tendon from the os calcis, and of tearing the upper end of the tendon from the triceps suræ muscles Stretching of the Achilles tendon should be done with a slow, steady pull The knee should be protected against knock-knee Kite warns that manipulations and wrenching may damage the articular surfaces of the bones and even crush the bones, thereby resulting in partial or complete ankylosis He warns also that if the ankle joint is flexed dorsally before the varus deformity is corrected, the results will be poor because the foot will yield in the transverse tarsal joint and not in the ankle joint, producing a "rocker bottom" In addition, he calls attention to the possibility that sudden changing of a foot from a rigid equinus position to a right angle by operation on the bone may so stretch the blood-vessels as to close their lumens, thereby causing gangrene in a part or all of the foot Division of the Achilles tendon may produce a "pipe-stem leg" Sir Robert Jones cautions against the removal of a large amount of bone, for while it allows perfect correction, it does not lead to as good function as can be obtained by other methods

Excessive manipulation, especially with the wrench, may be followed by aseptic necrosis of the astragalus At first the bone appears dense, but later normal

Braces—In the application of braces to club-feet, a heel that tends to slide up can be kept in place by applying within the brace a cuff supplied with two lateral straps The straps are passed through two slits in the sole of the brace, crossed underneath, and then brought forward in a figure-of-eight and secured The insertion of a wedge of leather about ¼ inch thick along the outer border of the sole will help to maintain a foot in the correct position In some cases, wearing of the right shoe on the left foot and *vice versa* is of value Several shoe firms make "club-foot" shoes Cole uses a club-foot shoe with elastic traction

TALIPES CALCANEOVALGUS

Talipes calcaneovalgus is the second most common type of congenital club-foot In this condition the forefoot is swung outward and the foot is in the heel-drop position Calcaneovalgus can usually be corrected with one or two plaster casts Operation on the bones is rarely necessary, if the treatment is begun early Nilsonne reported an un-

inner side of its former position where, by filling out the depression on the inner side of the foot, it prevents adduction of the forefoot like a bony block. Before the head is replaced the varus position of the os calcis must be corrected. If the cuboid blocks complete abduction of the forefoot, the removal of a bony wedge from the calcaneocuboid joint or directly through the cuboid is advisable. Care should be taken to avoid injuring the cartilage of the subastragalar and astragalo-scaphoid joints.

Kite's operation consists in removing a portion of the cuboid and the os calcis, cutting off the head and neck of the astragalus, replacing a small part of the astragalus, and then performing a subastragalar arthrodesis. In the cases of children under eight years of age, Kite prefers to postpone this operation.

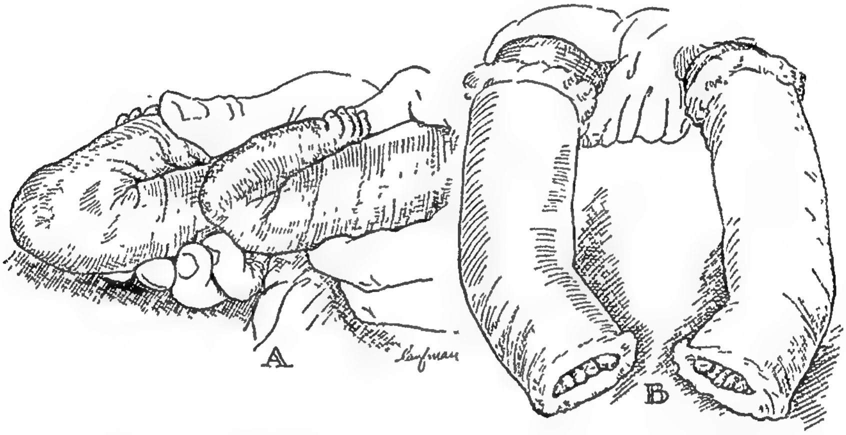


FIG. 84.—Congenital talipes calcaneus *A*, At birth. *B*, In corrective plaster casts applied within six hours after birth. (Drawn from photos.)

Decancellation of the Os Calcis, Astragalus, and Cuboid.—In the method recommended by Curtis, a small puncture wound is made in the neck of the astragalus, the anterior portion of the os calcis, and the cuboid, and the cancellous portions of these bones are removed with successively larger curets. From the cuboid, all of the cancellous portions are removed, but from the os calcis and astragalus only the anterior portions. The foot is then forcibly overcorrected by manipulation with a Thomas wrench.

Mayer's method of overcoming severe equinus deformity in cases of congenital club-foot and cases of paralytic equinus consists in driving through the posterior part of the os calcis, a nail or wire by means of which the os calcis can be firmly grasped, and performing a posterior capsulotomy. The nail is included in the plaster-of-Paris. (Fig. 81.)

In many severe cases, manipulation followed by lengthening of the tendon Achillis, plus a capsulotomy of the posterior portion of the ankle joint, will correct the deformity. In resistant cases in

older children, I have found the following procedure successful (1) wrenching, (2) plantar fasciotomy, (3) lengthening of the tibialis posticus tendon, (4) lengthening of the Achilles tendon, and (5) posterior capsulotomy of the ankle and astragalo-calcaneal joints

Accidents and Unfavorable Results —During manipulation there is danger of injuring the epiphysis of the lateral malleolus, of pulling off the attachment of the Achilles tendon from the os calcis, and of tearing the upper end of the tendon from the triceps suræ muscles Stretching of the Achilles tendon should be done with a slow, steady pull The knee should be protected against knock-knee Kite warns that manipulations and wrenching may damage the articular surfaces of the bones and even crush the bones, thereby resulting in partial or complete ankylosis He warns also that if the ankle joint is flexed dorsally before the varus deformity is corrected, the results will be poor because the foot will yield in the transverse tarsal joint and not in the ankle joint, producing a "rocker bottom" In addition, he calls attention to the possibility that sudden changing of a foot from a rigid equinus position to a right angle by operation on the bone may so stretch the blood-vessels as to close their lumens, thereby causing gangrene in a part or all of the foot Division of the Achilles tendon may produce a "pipe-stem leg" Sir Robert Jones cautions against the removal of a large amount of bone, for while it allows perfect correction, it does not lead to as good function as can be obtained by other methods

Excessive manipulation, especially with the wrench, may be followed by aseptic necrosis of the astragalus At first the bone appears dense, but later normal

Braces —In the application of braces to club-feet, a heel that tends to slide up can be kept in place by applying within the brace a cuff supplied with two lateral straps The straps are passed through two slits in the sole of the brace, crossed underneath, and then brought forward in a figure-of-eight and secured The insertion of a wedge of leather about ¼ inch thick along the outer border of the sole will help to maintain a foot in the correct position In some cases, wearing of the right shoe on the left foot and *vice versa* is of value Several shoe firms make "club-foot" shoes Cole uses a club-foot shoe with elastic traction

TALIPES CALCANEOVALGUS

Talipes calcaneovalgus is the second most common type of congenital club-foot In this condition the forefoot is swung outward and the foot is in the heel-drop position Calcaneovalgus can usually be corrected with one or two plaster casts Operation on the bones is rarely necessary, if the treatment is begun early Nilsonne reported an un-

usual case in which operation revealed a condition of the astragalus analogous to Köhler's or Legg-Calvé-Perthes' disease.

TALIPES EQUINOVALGUS—TALIPES CALCANEOVARUS

Equinovalgus and calcaneovarus deformities are uncommon. They are treated along lines similar to those described. Dickson corrected calcaneovarus by an osteotomy of the os calcis which was similar to that performed by Galeazzi for pes cavus except that the bone cut was in a lateral instead of a linear direction.

(Paralytic and spastic club-feet are discussed in Chapters XXV and XXVI respectively.)

CONGENITAL HALLUX VARUS

Operative Technique.—Under general anesthesia, Sloane makes an incision along the inner side of the right foot, extending from the proximal phalanx of the big toe to the middle of the first metatarsal. The tight band of tissue, which is primarily the abductor of the big toe, is severed. The big toe is then easily brought into its normal relationship with the rest of the foot. The metatarsophalangeal joint is opened medially, and a small overhanging ledge of bone is removed from the medial side of the metatarsal head. To prevent recurrence, a drill hole is made through the head of the first metatarsal and the base of the proximal phalanx, fascia lata is drawn through the holes to form a secondary reenforcing lateral ligament for the metatarsophalangeal joint of the big toe, and the joint capsule is reefed through a small incision laterally. The joint capsule is closed with chromic catgut and the skin with silk. The big toe is firmly bandaged in a correct position.

CALCANEO—CUBOID FUSION

Wagoner reported a case of bilateral fusion of the calcanei and cuboids in a boy of nine. Evidence of arthritic involvement of the tarsal articulation was lacking. The fusion between the two calcanei and cuboids was probably due to congenital absence of the calcaneo-cuboid articular cartilages.

COALITION OF THE CALCANEUS AND THE NAVICULAR

This is a condition, described by Slomann under the term "coalitio calcaneo-navicularis," in which the roentgenogram reveals complete union of the scaphoid on its lateral margin with the anterior portion of the os calcis.

COALITION OF THE ASTRAGALUS AND THE NAVICULAR

In my 1933 collection of interesting roentgen films of the foot and ankle I have antero-posterior, and lateral films of a case of congenital fusion of the astragalus and scaphoid bones I had never seen any reference to this anomaly (Fig 89)

In the October, 1943 issue of "The Journal of Bone and Joint Surgery" O Donoghue and Sell reported a case of bilateral symmetrical talonavicular synostosis It was the second instance in which the condition has been reported, and among the first where it has been substantiated with roentgenograms In 1879 Anderson reported the first case of bilateral talonavicular synostosis

O'Donoghue and Sell found reports of 5 cases of unilateral talonavicular fusions, 4 of these patients had other associated abnormalities

Boyd reported 4 patients with bilateral talonavicular synostosis seen at the Campbell Clinic In addition, each had a definite bony enlargement over the medial end of the navicular portion of the fused navicular and talus This enlargement was the one constant feature

Congenital talonavicular synostosis is of little clinical importance The absence of a talonavicular joint produces an increased strain on the joint between the combined bones and cuneiforms This excess strain may predispose to arthritic changes

Burman and Sinberg report the case of a man, aged thirty years, who had noted a bony growth all his life in each foot beneath the internal malleolus, so that it appeared that he had two ankle bones He had occasional aching in that area which seemed worse in rainy weather There have been no other cases reported except for the anatomic specimen of Pfitzner

Bilateral Congenital Talonavicular Fusion —Congenital fusion of the tarsal bones was discussed by Lapidus in the Journal of Bone and Joint Surgery, October 5, 1932 A case of congenital talonavicular fusion was likewise reported In July, 1938 he reported a case that was considered the third on record in which only bilateral congenital fusion of the talonavicular joint was present, the other tarsal joints being normal Review of the literature from 1932 to 1937 revealed only one more case of this apparently very rare malformation of the foot skeleton, that reported by Rothberg, Feldman and Schuster

In their patient, a girl eight years old, bilateral talonavicular fusion was demonstrated in routine roentgenograms Similar changes were discovered in the feet of the girl's brother, eleven years old, and also in those of her mother, thirty-one years of age The boy had never had any foot trouble, but he presented a medial projection over the talonavicular region The mother's feet appeared normal This

Fig. 85.—Congenital flat-foot.

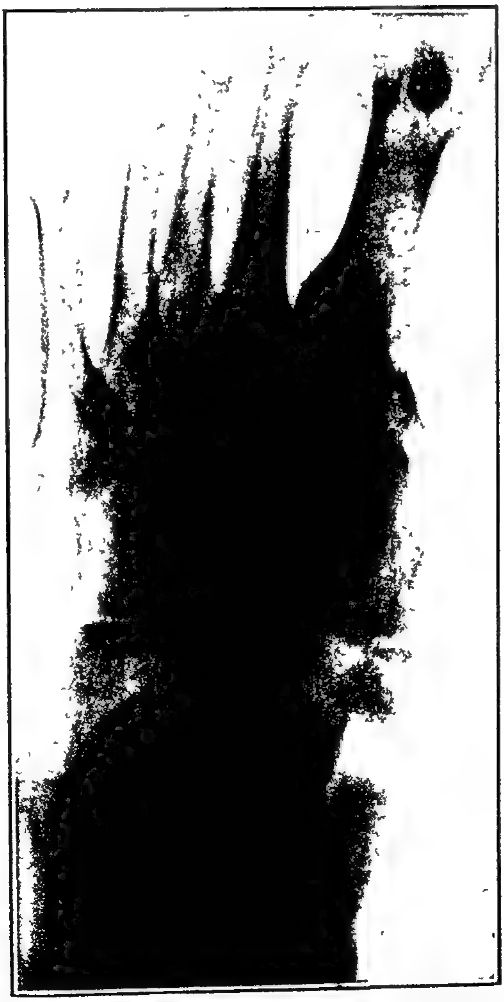


Fig. 86.—An accessory scaphoid bone caused pain in a flat-foot. Removal of extra bone was advised.

Fig 87 —A rare congenital anomaly eight well formed metatarsals and digits (Photo courtesy of Colonel Irving S Wright)

Fig 88 —Case of congenital rocker sole foot (Cook County Hospital Chicago)

Fig. 85.—Congenital flat-foot.

Fig. 86.—An accessory scaphoid bone caused pain in a flat-foot. Removal of extra bone was advised

Fig 87 —A rare congenital anomaly eight well formed metatarsals and digits (Photo courtesy of Colonel Irving S Wright)

Fig 88 —Case of congenital rocker sole foot (Cook County Hospital Chicago)

case is the only one on record which definitely proves the condition to be congenital and also hereditary.

Recently another case has come under the author's observation.

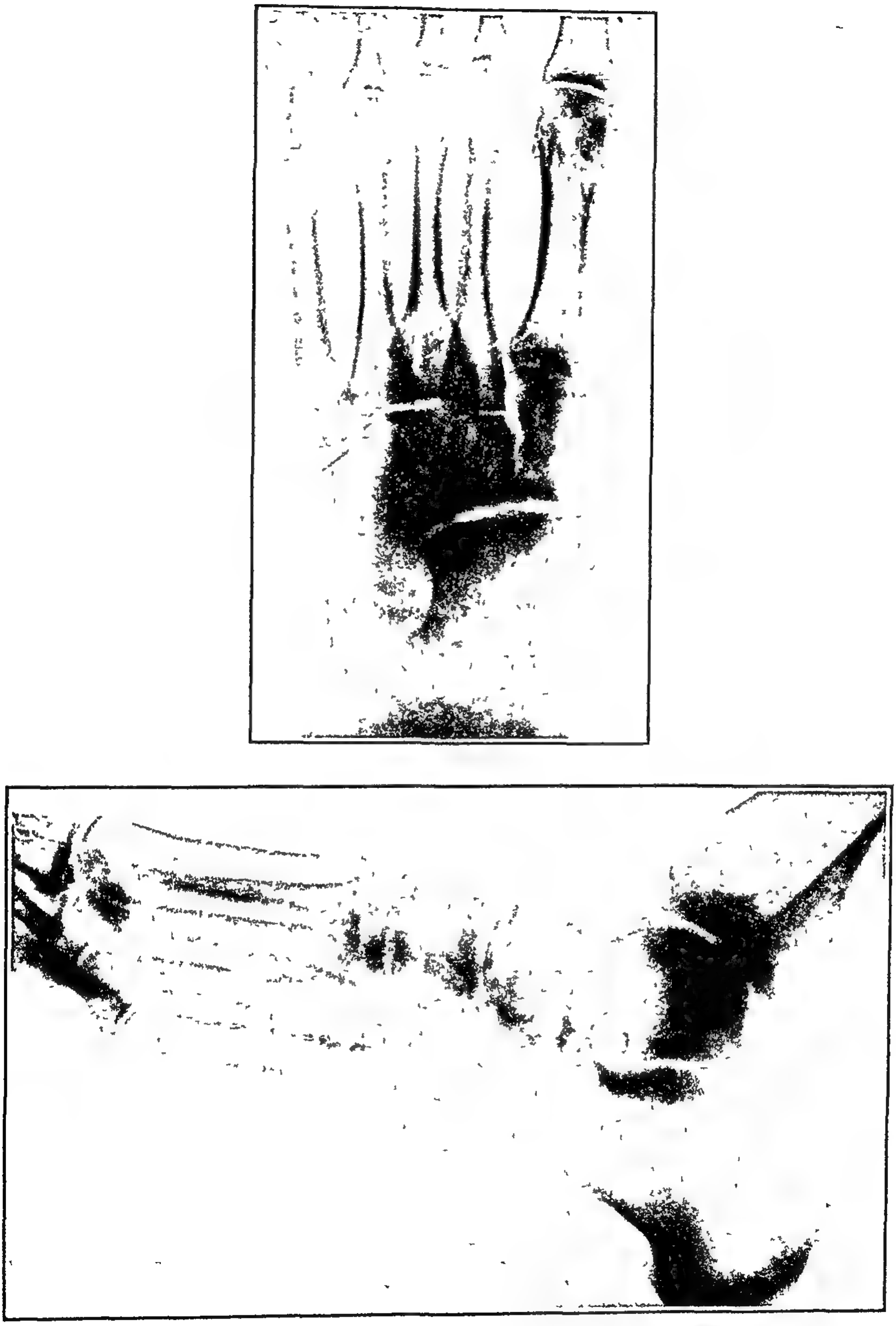


Fig. 89.—Congenital fusion of astragalus and scaphoid

BIFID OS CALCIS

Bifid os calcis is important from the clinical standpoint as it may be easily mistaken for a fracture, or some other injury to the foot. Ex-

treme precautions must be taken against mistaking it for fracture, in very young children A diagnosis of fracture may be made in the cases of children who are walking Roentgenograms of both feet should always be taken The anomaly is usually bilateral

CONGENITAL DISLOCATION OF ASTRAGALUS

Deutschlander described 28 cases of congenital dislocation of the astragalus On inspection, this condition looks like congenital flat-foot, but the chief changes are in the posterior portion of the foot There is a prominence in front of and below the internal malleolus, which is due to the medially turned head of the astragalus

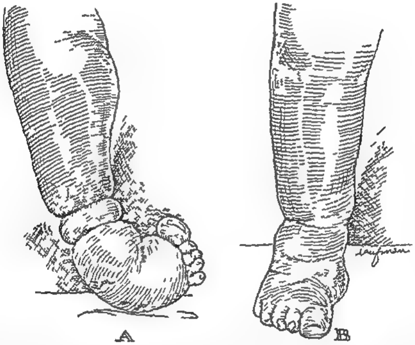


FIG 90—A Congenital constrictures of leg associated with bilateral club-foot B After correction of equinovarus deformity and plastic operation (Redrawn from Campbell Operative Orthopedics courtesy of C V Mosby Company)

CONGENITAL CONSTRICTING BANDS

Congenital constricting bands are most commonly found in the lower third of the leg I have seen them so striking that it looked as though all the soft tissues were completely encircled and compressed down to the bone However, it seems that there is always some circulation and nerve supply maintained, and based upon this fact, operations are performed and are usually successful Many times I have made three small incisions 120 degrees apart, and through these incisions inserted a blunt scissors and cut all constricting bands so that the entire circumference of the leg was free to function It is surprising how well these limbs do after this and other types of plastic operations

CONGENITAL PSEUDARTHROSIS OF THE TIBIA

Congenital pseudarthrosis of the tibia in children is a rare and extremely intractable condition occurring usually at the juncture of the lower and middle thirds of the shaft. There is pronounced shortening of the leg and foot with forward bowing of the tibia. Henderson studied 19 cases which fell into the following three groups: (1) fractures discovered at birth or within a few days after birth; (2) fractures sustained between the third month and fifth year of age; and (3) fractures sustained in middle or later childhood.

Wade called attention to an area in the bone resembling osteitis fibrosa which may be found at birth. The break may be succeeded by a pseudarthrosis with no attempt at bone regeneration, or by union which occurs by permeation of the affected area by new bone rather than by means of callus, and is soft and yielding for some years.

It is not merely a fracture that fails to unite but a pathological condition in the bone causing weakness and subsequent fracture. There is evidently a local metabolic bone lesion which may be cystic in nature. The bowing is probably secondary. In some cases an anomaly of the nutrient artery is an important factor. The bones involved present the characteristic roentgenographic appearance of a cystic formation which precedes fracture and resembles localized osteitis fibrosa cystica. The deformity is present at birth. When the fracture occurs either at or shortly after birth, it rarely heals spontaneously. The pathological changes are predetermined by an unknown embryologic anomaly diminishing the local power of osteogenesis. The tendency to this defect may be transmitted by the germ plasm.

Ordinarily operative treatment is not advised before the age of six years, and the chances for success by operation increase with age. The period of puberty is usually selected for surgery. In Colonna's 3 cases, in 2 of which bony union was obtained, the massive bone-graft technic was employed. The important technical points are wide excision of the pseudarthrotic area and the application of autogenous bone grafts. A double-wedged graft with osteoperiosteal and chip grafts including a supply of cancellous bone is recommended.

Henderson and Campbell use an autogenous massive graft held closely to the freshened fragments, with spongy bone packed about the fracture. Amputation should not be considered until every other method has failed, and certainly not until after puberty. Henderson reported 5 successful operations. Phemister inserts long heavy grafts in two or four positions.

Ghormley and his co-workers have had considerable success following the use of homologous bone grafts employing the mother's tibia.

Congenital pseudarthrosis of the tibia and fibula is a false joint or fracture of the tibia and fibula in children, which seldom, if ever heals spontaneously, and can be induced to unite only with great difficulty by bone grafting

It is a "congenital" process, in that children are born with an abnormality of the tibia The tibia before it has fractured shows an anterior and lateral bowing, with the lower half of the shaft smaller and more dense, and at times cystic Brailsford described the situation as a defect in the architect's plans for the tibia, and also in the building materials themselves Certain of the bone elements have entirely lost their power to reproduce bone In fact, it seems that there is a hyperactivity of the bone-destroying elements

In 15 cases reported by Kite six showed "cafe-au-lait" spots and one of these a few neurofibroma molluscum Henderson divides these cases into three groups, and puts these older ones in a group to themselves Gasne divides them into four groups The graft is usually placed on the side of the tibia next to the fibula, so that it is buried deep beneath the muscles, which gives it a better blood supply

OTHER CONGENITAL DEFECTS

The subject of congenital absence or defects of bones is of interest not only from the point of view of the biologist but also from that of the roentgenologist and surgeon The following terms are employed

Agenesia —Failure of skeletal development

Hypoplasia —Partial deficiency of growth

Ectrodactylia or Ectrodactylism —Congenital absence of any of the toes

Ectromelus —A monster characterized by aborted or imperfect limbs There are all degrees, from entire absence of a limb to simple shortening Hemi-ectromelia is the unilateral condition

Hemimelus —Deficient or atrophied legs, and feet with normal thighs

Phocomelus —Shortened or rudimentary thighs The feet are attached almost directly to the trunk

The cause of these conditions is unknown There are many theories but none is satisfactory

Local *giantism* means the overgrowth of a portion of an extremity It may affect a foot, ankle, leg, or one or more toes The cause is unknown Many cases require plastic operations or amputation

Congenital "Pigeon-Toes" and Bow-legs —I have seen several newborn babes with severe bow-legs and pigeon-toes which were corrected by wearing plaster casts for a period of ten or fourteen days

The Flexible Flat-Foot.—The flexible flat-foot is found in: (1) infants; (2) children; (3) adolescents; (4) adults, but rarely in the (5) aged.

The flexible flat-foot presents specific problems in regard to shoe fitting, modification of shoes, supports, and exercises. Some flexible flat-feet require surgery but this should not be undertaken until proper conservative measures have been tried.

Morton's platform for short first metatarsal is recommended highly.

Removable arch supports have the advantage of being transferable from one shoe to another. They are not transferable from rights to lefts however.

Schwartz of Rochester, N. Y. has made the most intensive and precise study on gait over a period of twenty years of any person in the world.

Hibbs Muscle Bound Foot.—This is characterized by a flat-foot with a short Achilles tendon. Hibbs's operation was based on the theory that the patient could not exercise until his Achilles tendon was lengthened.

Ryerson says "there is no such thing as a short Achilles tendon." The structural shortening is in the muscle bellies.

In some cases it is advisable to:

1. Release the pull of the posterior tibial tendon.
2. Fuse the astragalo-scaphoid joint.
3. Transplant the posterior tibial tendon.

In many cases, valuable information can be obtained from a lateral roentgen-ray projection of the foot and ankle, made while the foot is forced into dorsiflexion.

A Few Remarks Regarding Flat-feet

Flat feet may present a complex problem.

Not all flat-feet are alike.

Not all flat-feet cause disability.

The two important factors are:

1. Skeletal architecture.
2. Soft tissue structure and function.

These two factors are reciprocal.

Several important items in understanding the flat-foot problem are:

1. The history.
2. Valgus deformity.
3. Short achilles mechanism.
4. Hypermobility of foot components.
5. Spasticity of foot components
6. Instability.
7. Variations in degree of deformity and disability.

Painful Feet in the Army—A surprisingly large number of soldiers who had been inducted into the Army developed the complaint of "painful feet" during the period of their basic training. Most of these symptoms according to Bingham were due to minor functional strains from the physical conditioning program. These responded very well to the treatment of the battalion or dispensary surgeon with rest and conservative management. The more severe cases were referred to the Orthopedic Clinic, and in a large training camp hospital they can be divided into two groups (1) traumatic lesions of the feet, severe strains, sprains and fractures, and (2) postural foot disorders and skeletal abnormalities. This second group generally required the most careful diagnosis and prompt treatment if men thus affected were to be salvaged for some useful type of military service.

Ten per cent of the soldier patients in the Orthopedic Clinic of the Station Hospital at Camp Van Dorn, Mississippi, who complained of "painful feet" were found by Bingham to have "Morton's syndrome."

This disorder is characterized by metatarsalgia and midtarsal pain caused by a congenital developmental shortening or relaxation of the first metatarsal segment of the foot.

Diagnosis can be made by physical examination and verified by roentgen-ray films in every case. Treatment consists in supplying an individually fitted "compensating insole" which provides a weight-bearing platform for the first metatarsal head.

Of 100 soldiers treated by this method, 76 were able to continue full military duty, "general service," while wearing the "compensating insoles."

CHAPTER VI

STATIC DEFECTS AND DEFORMITIES

DISTURBANCES OF THE LONGITUDINAL ARCH

THE chief causes of disturbances of the longitudinal arch are heredity, bad posture, injuries, and infections. Bohm has shown that the foot of a human embryo at the beginning of the third month possesses many of the features noted in congenital flat-foot and in the foot of the ape. Lapidus believes that the occurrence of congenital flat-foot may be explained on the basis of arrest of its embryonal development in the early ape-like stage. The symptoms of flat-foot are fatigue, pain and limp. The combination of arthritis and flat-foot is serious. Traumatic flat-foot is usually due to a mechanical injury attended by marked disability. Circulatory disturbances engrafted upon a flat-foot present difficult problems. The rigid foot is incapable of performing normal movements. "Foot strain" is a term indicating overactivity of a normal foot or moderate activity of an abnormal foot. "Pes cavus pronatus" means a high longitudinal arch that is pronated. The term "ankle valgus" means medial deviation of the ankle beyond the normal and should not be used as a synonym for "flat-foot." The difference between a weak foot and a flat-foot is that in the latter there is pronation whether the foot is bearing weight or not, active supination is lost, and passive supination, though possible, is painful; whereas in the weak foot pronation occurs only on weight-bearing and both active and passive supination are possible.

FLAT-FOOT

The causes of flat-foot include heredity, static defects, traumatic lesions, infections, occupational trauma, endocrine disturbances, and obesity. The treatment includes absolute or partial rest, local applications of an anodyne lotion and fomentations, modification of the shoes, proper walking, exercises, support, contrast sprays, manipulation, open operations on the bones and soft tissues, supination, strapping, forceful manipulation, the application of plaster-of-Paris casts, protection, and the use of crutches. The treatment of rigid flat-foot includes rest in bed, local applications of an anodyne lotion, supination by the physical therapist or manipulation under anesthesia, support, and exercises. The treatment of the arthritic type of flat-foot includes the eradication of foci of infection, the correction

of metabolic and endocrine disturbances, rest in bed, the application of an anodyne lotion, fomentations, and plaster casts, modification of the shoes, and the use of resilient supports within the shoes

Flat-foot is important because of its primary manifestations and its secondary effects

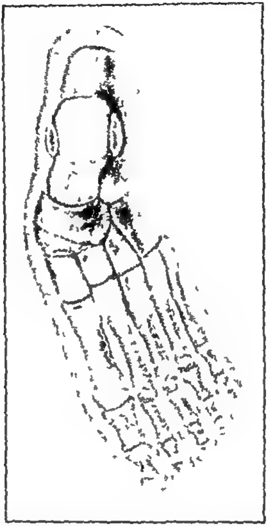


FIG 91—Superior view of the bones of the foot in cases of flat foot Note especially the changes in the head of the astragalus and the scaphoid (Courtesy of Dr Michael Hoke)

Etiology—Heredity is an important etiological factor According to my experience, the paternal parent is usually the one responsible Congenital anomalies are frequent in cases of flat-foot The most common is the accessory scaphoid bone Congenital fusion of the calcaneus with the scaphoid and of the calcaneus with the cuboid may be found Congenital calcaneus is very common Any condition that weakens the musculature may cause flat-foot I have seen typical cases of post-diphtheritic peripheral neuritis followed by flat-foot

According to Sir Arthur Keith, flat-foot is a reversion to type resulting from the loss of a recently evolved function, one which man has obtained late in his history.

In long, slender, rapidly growing feet, especially in girls, a definite type of weak, pronated, or flat-foot may appear with adolescence. Focal infection, such as tonsillitis, or any infectious disease may cause a painful flat-foot by producing a toxic relaxation of supporting structures unprotected by proper prophylactic measures. Infections may cause a toxic arthritis with resulting rigid valgus deformity which is resistant to treatment. Three anatomical factors in the production of weak foot are a short Achilles tendon, hypertrophy of the inner end of the scaphoid, and an os tibiale externum.

Left Right

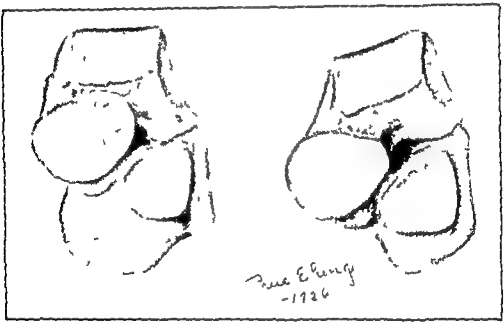
FIG. 92.—Left, rear view of a normal foot showing the relationship of the tibia, fibula, astragalus and os calcis Right, rear view showing relation of the tibia, fibula, astragalus and os calcis in talipes valgus. (Courtesy of Dr. Michael Hoke.)

Poor sitting posture such as is shown in Figure 23 is conducive to poor foot posture.

Flat-foot caused by obesity is due to two factors: (1) the strain of

an excessive load when there is a disproportion between the weight to be carried and the size and power of the feet and lower part of the legs, and (2) the glandular imbalance found in conditions such as the dystrophia adiposogenitalis of Froelich in which, usually in association with talipes valgus, there is genu valgum. Trauma may result in a pronated foot. Anterior poliomyelitis is a frequent cause of valgus deformity. Although armies are motorized very extensively at the present time, the condition of the soldier's feet is still very important.

Anatomy.—The pathological anatomy of the pronated foot consists of inward rotation of the superior portion of the os calcis. The insertion of the Achilles tendon is lateral. It is difficult to say whether this



a *b*

Fig. 93.—Relationship of the head of the astragalus to the os calcis in the (*a*) normal foot and (*b*) valgus foot. (Courtesy of Dr. Michael Hoke.)

is cause or effect. The upper border of the astragalus is tilted medialward and the inner border is lower than the outer so that the weight strikes it a glancing instead of a square blow. This is unfavorable mechanically. The peroneal tendons are contracted because they are allowed to shorten. (A contracted muscle or tendon is easier to treat than a stretched one.) The anterior and posterior tibial tendons are stretched and lose their power. It is a physiological law that when a normal tendon is overstretched it becomes weaker, whereas when it is allowed to shorten it usually contracts and becomes *stronger*. This law applies equally to the capsules of the joints and the ligaments. In the pronated foot, the external lateral ligament and the external portion of the capsule of the joint are shortened and contracted, and the

internal lateral ligament and the internal portion of the capsule are stretched and weakened. The deltoid ligament extends between the scaphoid and astragalus, the scaphoid and os calcis, and the astragalus and os calcis. Moreover, the ligament between the cuboid and the os calcis is often contracted. There is gaping of the bones on the inner border of the foot, namely, the scaphoid, os calcis, astragalus, and first cuneiform. There is compression of the bones on the outer border of the foot, namely, the cuboid, os calcis and astragalus. The bones of the mid-tarsal region, especially the scaphoid and the first and second cuneiforms, are rotated downward and inward. The forepart of the foot is abducted; the foot is everted and therefore in valgus position.

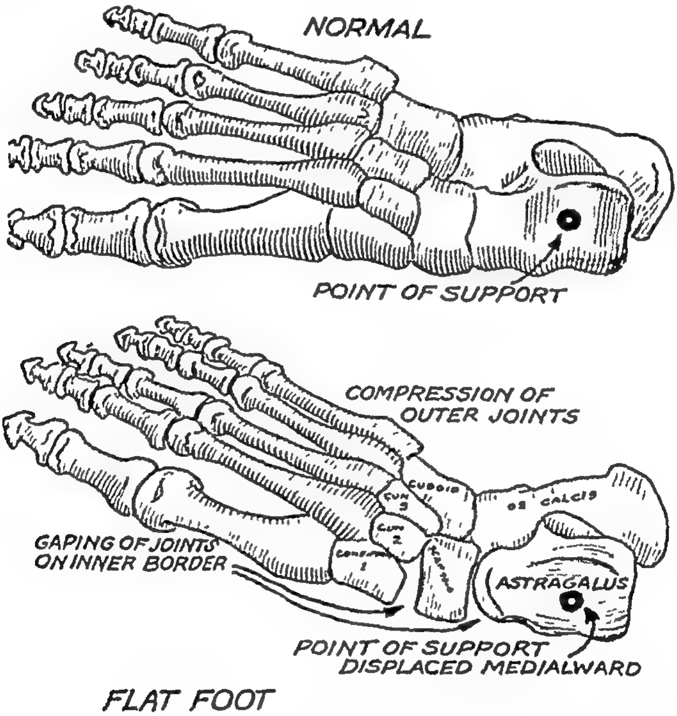


Fig. 94.—The bones of the foot seen from above in the normal and in the flat-foot position. Looking at the top, you see the point of support in the normal foot bears a definite relation to the astragalus. This spot takes the weight of the whole body. In the flat-foot you see that the point of weight-bearing is shifted downward medially and the astragalus is turned. Notice the gap that occurs between scaphoid and cuneiform I and between scaphoid and cuneiform II. On the outer border you have compression. You may have pain on both sides. (Lewin, courtesy of Am. Jour. Dis. Child.)

In children, the general condition of the muscles may be below par; there may be a generalized amyotonia. Knock-knees are more common than bow-legs. The back is frequently round. The mother says the child does not walk properly, is awkward, and has "weak ankles," and that the ankle bones protrude. A bone (scaphoid or sustentaculum tali) seems to be displaced, the ankles "interfere," and the child complains of early fatigue and refuses to run and play. Pain is usually

absent because the foot is flexible If arthritis develops, flexibility is decreased and a rigid valgus foot results

Objectively, the front view shows pronation, that is, downward and inward rotation of the mid-tarsal region, abduction of the forefoot, and eversion, in other words, a valgus deformity A plumb line dropped from the middle of the patella falls inside of the normal point The rear view reveals medialward curving of the Achilles tendon, the so-called Helbing sign A plumb line dropped from the middle of the popliteal

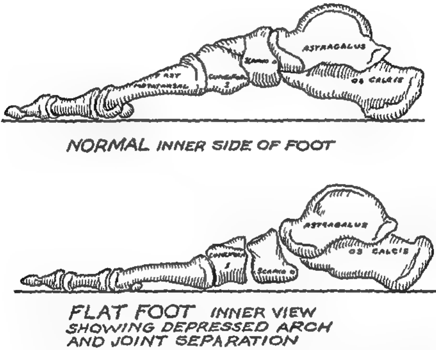


FIG 95 —The bones of the foot seen from the inner side in the normal and in the flat-foot At the top you see a view of the normal inner border of the foot the astragalus scaphoid cuneiform first metatarsal sesamoid first and second phalanges In the *flat-foot* there is an arch depression the bones become separated You can visualise what happens to the ligaments This is normal in the colored fellow's foot With the foot on the ground there is no strain on it You can see how the person who has at one time had an arch which was normal when he experiences strain he suffers pain because the ligaments are stretched and the muscles weakened When the muscles weaken strain is thrown on the ligaments so that in addition to muscle pain he has ligament stress and strain (Lewin courtesy of Am Jour Dis Child)

space is not parallel with the Achilles tendon The heel is flattened and rotated, in some cases resembling the "heel of an ape," and there is prominence of the scaphoid region It is possible to have one valgus and one varus deformity, namely, a flat-foot on one side and a club-foot on the other

The value of footprints has been overestimated from the standpoint of both diagnosis and progress The print of the new-born *infant is* misleading as it usually looks flat, whereas if the foot of a new-born infant is cross-sectioned it will show a definite bony arch obliterated

by a fat pad. One may find a foot with a high arch but in a position of pronation, to which the term "pes cavus valgus" or "pes cavus pronatus" may be applied.

Symptoms.—The chief symptoms of flat-foot in adolescents and adults are fatigue and pain or ache. The pain is worse on standing than in walking, the reason for this being that in walking, chiefly the

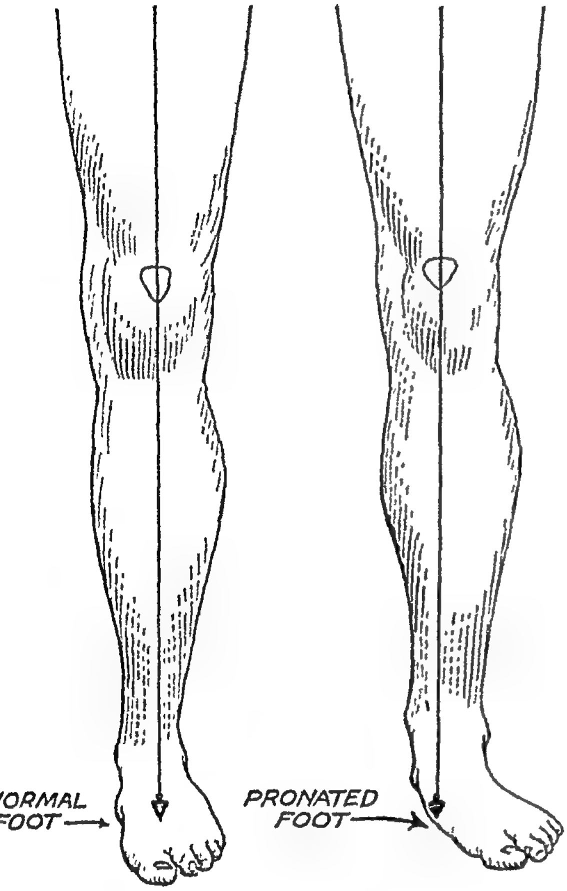


Fig. 96

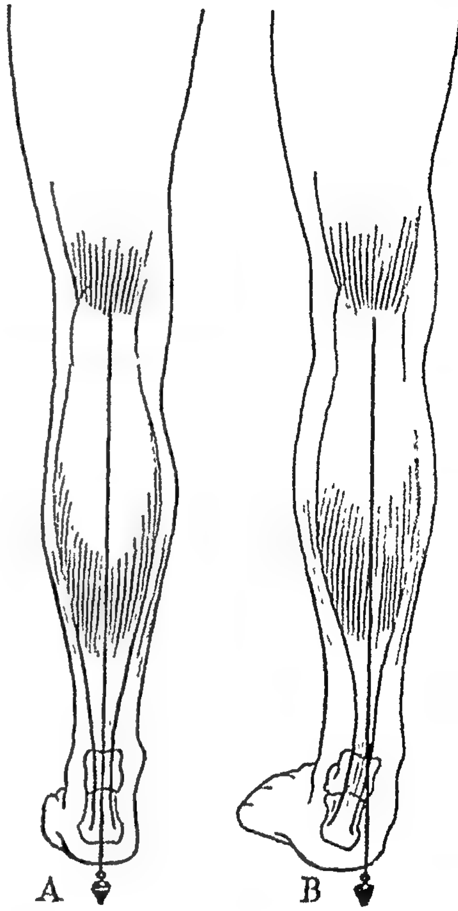


Fig. 97

Fig. 96.—Showing the position of a plumb line dropped from the middle of the patella in the normal and flat-foot. (Lewin, courtesy of Am. Jour. Dis. Child.)

Fig. 97.—The position of a plumb line dropped from the middle of the popliteal space in the normal A, and in the flat-foot B. (Lewin, courtesy of Am. Jour. Dis. Child.)

If you drop a plumb line from the middle of the patella it should bisect the tibia and the astragalus, and follow toward a point where a line drawn from the crotch of the first and second toes would meet that line.

Here is the normal plumb line drawn from the middle of the patella. The pronated foot line is the one you see on the right. That throws him off balance. The astragalus receives a glancing blow instead of a straight on blow.

In the rear view, the line bisects the calf, is parallel with and bisects the astragalus and the achilles tendon. This is the flat-foot from the rear. The astragalus is turned. Very often you get an accurate impression of the mechanical trouble from the posterior as well as from an anterior view.

muscles are used whereas in standing, the muscles, which are weak, relax and throw the strain on the ligaments which are not sufficiently

strong to withstand it Standing is therefore associated not only with muscular pain, but also with ligamentous strain Merrill uses the term "tarsalgia" Tenderness is present especially over the calcaneo-scaphoid ligament, but also over the astragalo-scaphoid ligament and the ligament between the scaphoid and internal cuneiform

There is sensitiveness to movement On inspection, the arch of the foot may or may not be flat or depressed Rich says that 80 per cent of foot valgus occurs in the ankle joint, and recommends describing it by the term "ankle valgus" On the inner part of the foot there may be a *prominence* with its center in the region of the tubercle of the scaphoid bone

Feiss' line connects the postero-inferior aspect of the internal malleolus and the distal end of the plantar surface of the first metatarsal In the *normal* foot the point of the scaphoid is about ½ inch below the line described In all cases of cavus this point is found above the normal position, while in flat-foot it may be 1 or 1½ inches below the line (Fig 105)

In examining the feet of nurses, Lovett found it impossible to tell with any certainty by *routine examination* whether or not a foot was likely to cause trouble The only reliable information was obtained from the imprints seen through glass He therefore adopted the practice of using in all examinations a plate of glass with a mirror placed underneath at an angle The nurse was examined with her feet bare, facing the observer, on a glass plate raised 18 inches from the floor In her natural standing position the blanched weight-bearing surfaces of the feet were observed through the glass, being reflected in the mirror The pressure surface was recorded by a pencil sketch in the record The contact surfaces were of three types By inspection of the feet from in front, the degree of rolling-in (pronation) of the foot was noted and recorded as the nurse stood in the natural position In many cases the condition of the circulation of the feet was noted A record of calluses, bunions, crumpled toes, ingrowing nails, and other signs of abuse was made Finally, the general appearance of the foot and its probable usefulness were recorded as excellent, good, fair, suspicious, or poor A flat-foot may be perfectly serviceable whereas an apparently well-balanced foot may become painful

There is no exclusive type of arch that can be considered the *normal* The height and shape of the longitudinal arch do not determine the strength or usefulness of the foot In the diagnosis of arch strain or weakness, impression records of the longitudinal arch may be misleading

In cases of acute flat-foot, the presence of arthritis should always be suspected Many persons with flat-feet state that they feel more

comfortable in new shoes than in shoes which have been worn for a considerable time and give less support.

Achillo-bursitis, which is usually accompanied by strain on the longitudinal arch, has been referred to by American tourists in Europe as "cathedral heels."

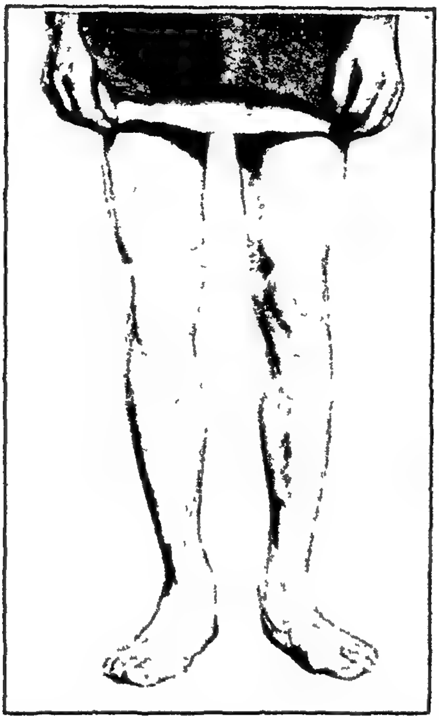


Fig. 98.—High degree of pronation or flat-feet. Note large exostoses of the first metatarsal heads with bunions and hallux valgus. This man was injudiciously admitted to the Army in 1917, and was examined by the author at Camp Grant.

He was sent in from one of the regiments because he said he couldn't march, he couldn't drill and he couldn't stand in formation. He was about to be courtmartialed as a malingerer because he "wouldn't stand up" to Army routine. He was sent to the base hospital where I first saw him. I asked him to stand with his feet parallel and then tip his weight to the outer borders of his feet. This he could not do. It is a very simple test but it tells a great deal. A person with rigid flat-feet can't do it, one with flexible flat-feet can. A person with rigid flat-feet loses the power to supinate.

This gives you an idea of the discomfort, deformity and disability caused by rigid flat-feet. I have seen persons with two artificial limbs who walked more gracefully and comfortably than this fellow did. (Lewin, Principles and Practice of Physical Therapy, courtesy of W. F. Prior Company.)

Diagnosis.—The various conditions which must be differentiated from flat-foot are: injury, toxic arthritis, synovitis, bursitis, tendinitis, poliomyelitis, Köhler's tarsal scaphoiditis, apophysitis of the os calcis, and tuberculosis. When a rheumatoid person gets flat, painful feet, it is different from rigid flat-feet. If you put them to sleep you can supinate them. With rigid flat-feet it is difficult to do that without performing extensive surgery.

Prognosis —The prognosis in flat-foot depends on the duration of the treatment In the rigid type the course is protracted

Treatment —In the treatment it is necessary to teach proper walking, increase the power of the supporting structures, increase the local circulation, support the weakened structures produce supination, and, in children, correct any associated condition such as knock-knee or bow-legs The indications are met by proper shoes, exercises, massage,

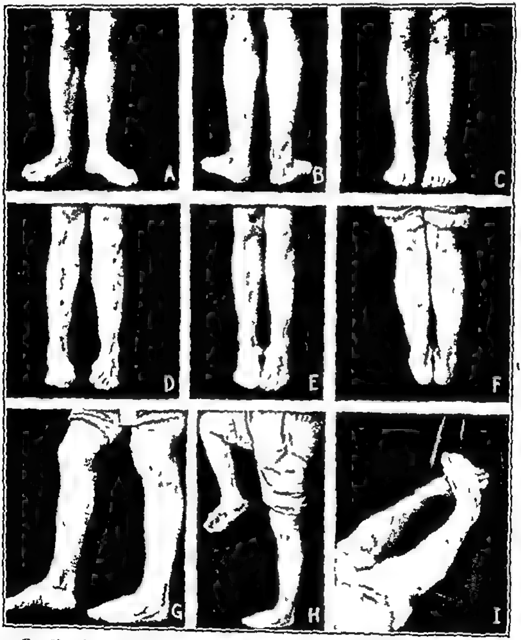


Fig 99 —(Top) *A* and *B* incorrect standing posture *C* correct posture (Middle) Standing exercises for flat feet *D* Exercise No 1 *E* exercise No 2 as seen from the front *F* exercise No 2 as seen from the rear (Bottom) Walking exercises for flat-feet *G* Exercise No 3 *H* exercise No 4 *I*, resistive exercise No 6B The last exercise strengthens the anterior and *posterior tibials and the flexor* hallucis muscles

contrast foot-baths. felt pads, plaster-of-Paris casts, braces, and operation. The treatment of painful feet and ankles due to arthritis is described on page 462.

It is important to impress on the patient that he should wear a proper shoe for a part of the time at least. The shoe should have a straight last, a medium width, a rigid or semi-rigid shank, a round toe, and a heel of moderate height. My advice to women patients is that they should wear proper shoes for walking and around the house, but for dress occasions, they may wear almost any shoes that fit their feet if they are willing, thereby, to undo some of the good derived from the wearing of proper shoes at other times.

While it is not necessary for most children to have corrective shoes, it is important that all children be properly fitted with shoes that are correct. Unlike the shoes of adults, which are often

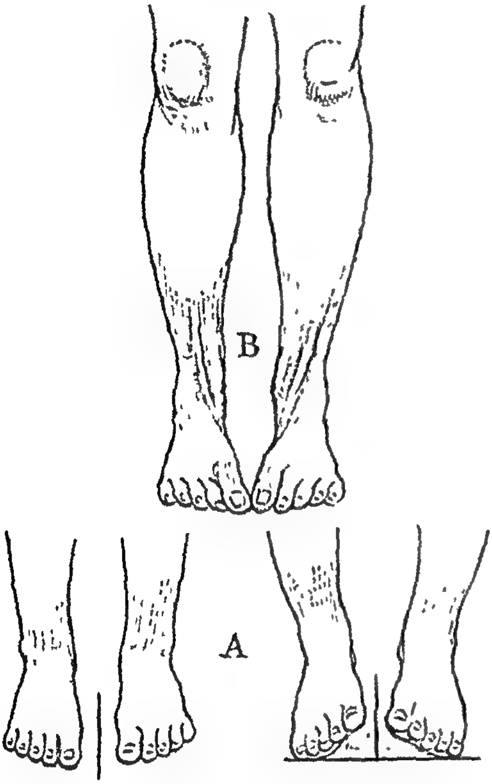


FIG. 100

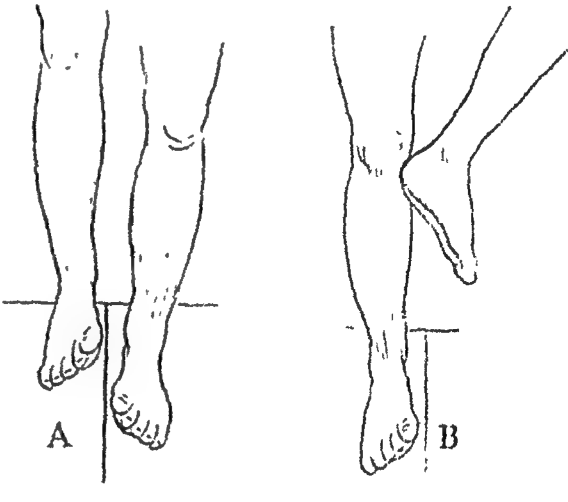


FIG. 101

FIG. 100.—Longitudinal arch exercises Nos. 1 and 2.
FIG. 101.—Longitudinal arch exercises Nos. 3 and 4. (Lewin, courtesy of Am. Jour Dis. Child.)

of improper shape, the shoes of children are so well standardized that their shape is usually correct. The difficulty arises in the fitting. So many inexperienced clerks are fitting children's feet that many children are fitted improperly. Proper fitting is difficult because children often outgrow rather than outwear their shoes.

Thomas Heel.—One of t [illegible] ant modifications of the shoe is the application of a spec [illegible] sec [illegible] s ago by H. O. Thomas. Each patient [illegible] el. There are four dimensions: the inn [illegible] of the os calcis

to the anterior border of the scaphoid tubercle, the outer border length from the tip of the os calcis to a perpendicular line dropped from the anterior border of the external malleolus, the inner border height,

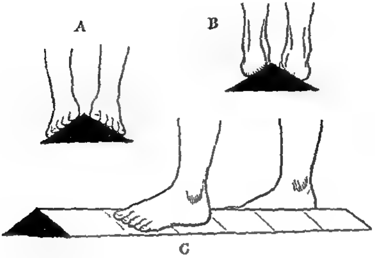


FIG 102 —Supination board An isosceles triangle 6 inches high and 8 feet long *A* Front view *B* Rear view *C* Side view (Lewin courtesy of Am Jour Dis Child)

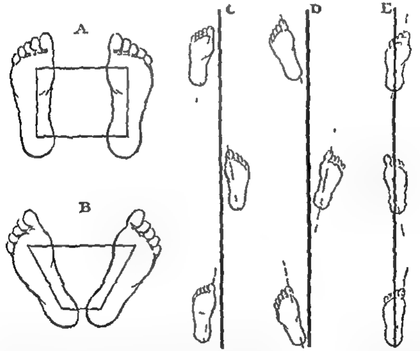


FIG 103 —*A* Four square position standing which is correct *B* Military position, standing incorrect *C* Four square position walking correct *D* Military position, walking incorrect *E* Indian position walking (Ellis courtesy of Am Jour Diseases of Children)

from $\frac{1}{8}$ to $\frac{1}{4}$ inch higher than the normal height of the heel, and the outer border height, the normal height of the heel for the subject's shoe (Fig 40) I have obtained the best results from measuring

contrast foot-baths, felt pads, plaster-of-Paris casts, braces, and operation. The treatment of painful feet and ankles due to arthritis is described on page 462.

It is important to impress on the patient that he should wear a proper shoe for a part of the time at least. The shoe should have a straight last, a medium width, a rigid or semi-rigid shank, a round toe, and a heel of moderate height. My advice to women patients is that they should wear proper shoes for walking and around the house, but for dress occasions, they may wear almost any shoes that fit their feet if they are willing, thereby, to undo some of the good derived from the wearing of proper shoes at other times.

While it is not necessary for most children to have corrective shoes, it is important that all children be properly fitted with shoes that are correct. Unlike the shoes of adults, which are often

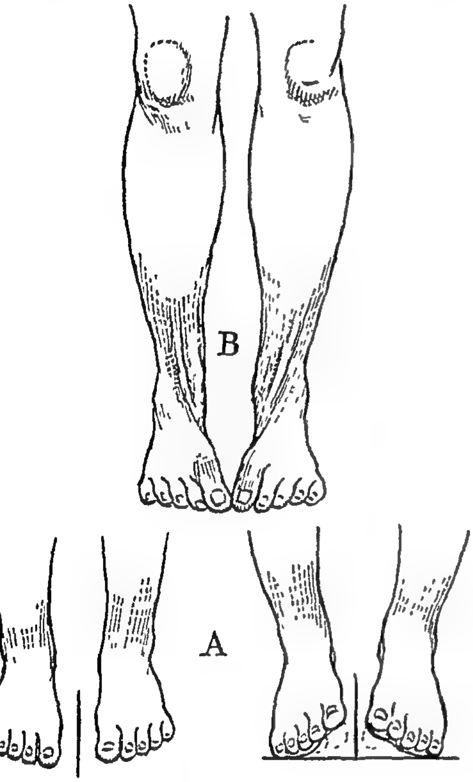


FIG. 100

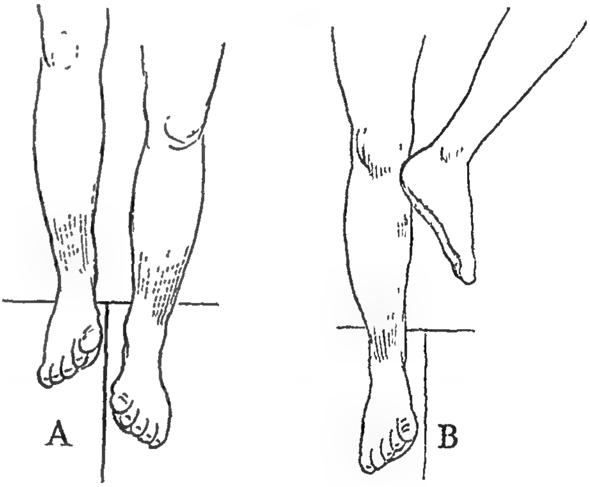


FIG 101

FIG 100 —Longitudinal arch exercises Nos. 1 and 2.
FIG. 101.—Longitudinal arch exercises Nos. 3 and 4. (Lewin, courtesy of Am. Jour Dis. Child.)

of improper shape, the shoes of children are so well standardized that their shape is usually correct. The difficulty arises in the fitting. So many inexperienced clerks are fitting children's feet that many children are fitted improperly. Proper fitting is difficult because children often outgrow rather than outwear their shoes.

Thomas Heel.—One of the important modifications of the shoe is the application of a special heel devised many years ago by H. O. Thomas. Each patient must be measured for this heel. There are four dimensions: the inner border length from the tip of the os calcis

to the anterior border of the scaphoid tubercle, the outer border length from the tip of the os calcis to a perpendicular line dropped from the anterior border of the external malleolus, the inner border height,

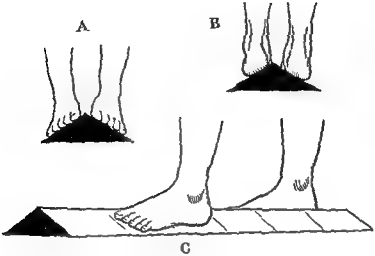


Fig 102 —Supination board An isosceles triangle 6 inches high and 8 feet long *A* Front view *B* Rear view *C* Side view (Lewin courtesy of Am Jour Dis Child)

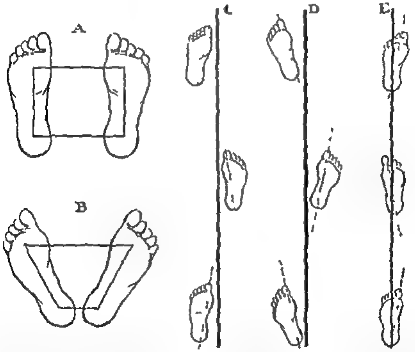


Fig 103 —*A* Four square position standing which is correct *B* Military position, standing incorrect *C* Four square position walking correct *D* Military position, walking incorrect *E* Indian position walking (Ellis courtesy of Am Jour Diseases of Children)

from ⅛ to ¼ inch higher than the normal height of the heel, and the outer border height, the normal height of the heel for the subject's shoe (Fig 40) I have obtained the best results from measuring

the shoe and estimating these distances. The Thomas heel is used to compel the patient to walk over the outer border of the foot. When properly made, it forces him to a proper walking angle. Only infre-

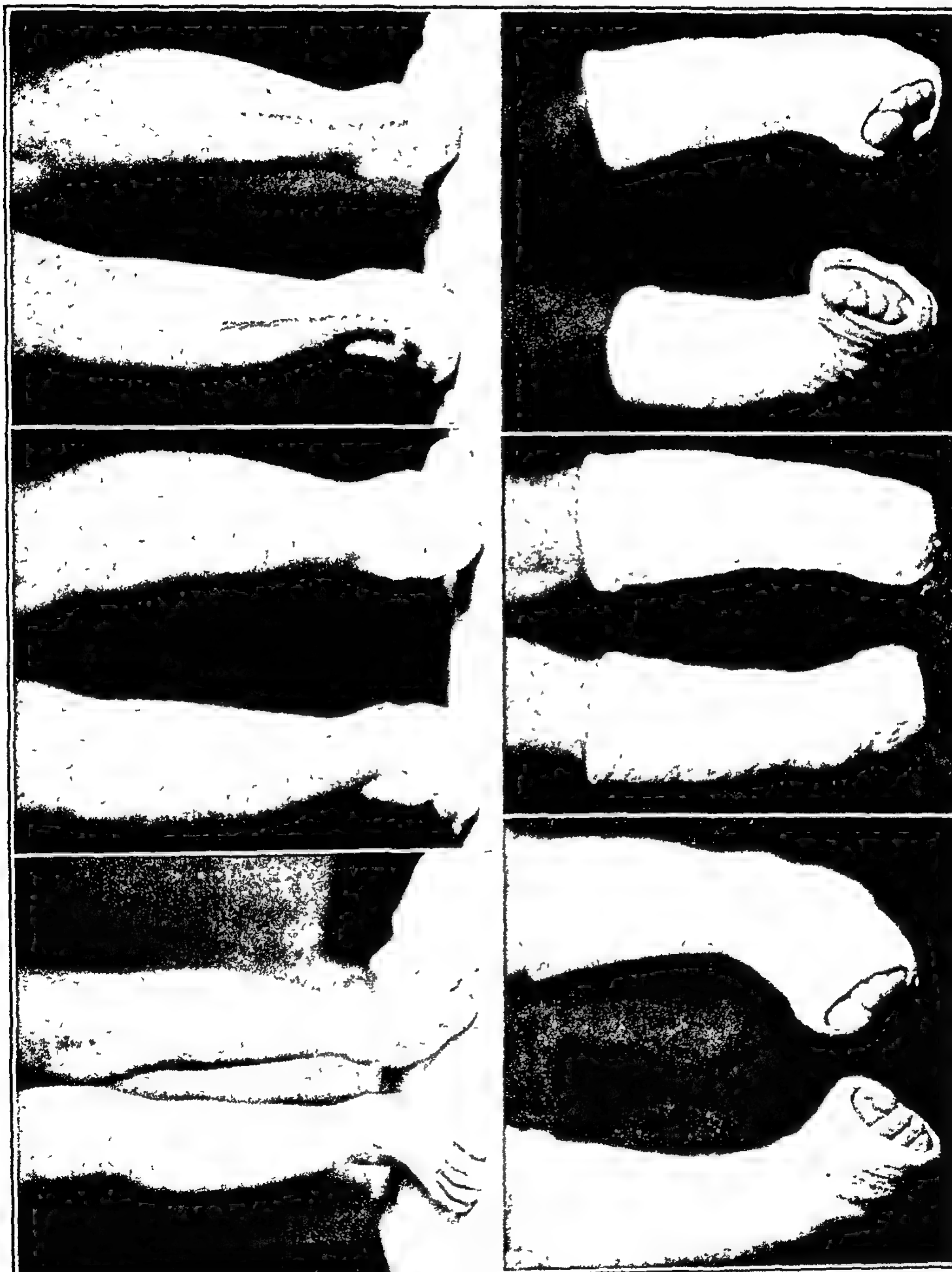


FIG. 104.—Severe case of flat-feet in a boy aged two years, showing pronation, ankle valgus, positive Helbing sign. The lower figures show the child in the first of a series of plaster casts. The feet are simply inverted and then the next stage is to pronate the forefoot but still maintain supination of the heel and mid-tarsal region.

quently should the inner border of the sole be tilted, but in many cases the outer border should be raised from $\frac{1}{8}$ to $\frac{5}{16}$ inch to force the big toe flat. This should be done to a flexible shank shoe.

Steindler described a supination-compensation torsion of the forefoot This is obtained by means of a special heel which tilts the mid- and hind-foot to the outer border, and by a wedge along the outer border of the sole which forces the forefoot into the position of adduction so that the big toe rests on the ground The combination of a Thomas heel and a tilted notched rubber metatarsal crescent on a flexible-shank shoe is very effective (Fig 42)

In cases of "weak ankles," re-inforced uppers attached to the counters are helpful To prevent pressure areas, the leather re-inforcement must be carefully moulded or cut out over the malleoli Ankle "corsets" made of canvas re-inforced with whalebone are often helpful

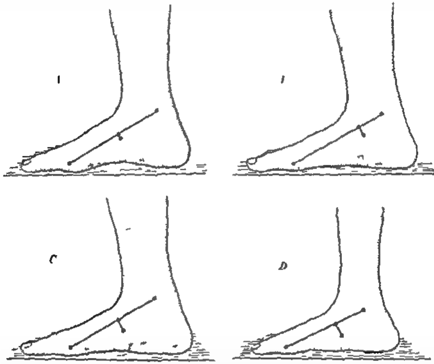


Fig 105—*A* Sketch of the foot without weight-bearing The posterior inferior corner of the internal malleolus is connected with the lower tubercle on the head of the first metatarsal by a connecting line to the scaphoid tubercle *B* Flaccid flat-foot of moderate degree (non-weight-bearing) in a subject aged ten years The tubercle is ¾ inch below the connecting line *C* Sketch of same foot with weight-bearing Note the increased distance of the scaphoid tubercle from the connecting line *D* Rigid flat foot marked (non weight-bearing) The tubercle is 1 inch below the connecting line (Redrawn from Feiss)

temporarily (Fig 57) I frequently recommend that the inner border of the counter of the shoe be carried forward to include the scaphoid and first cuneiform bones

Gymnasium shoes should be worn only for gymnastics They should include the ankle, and should have felt pads inserted Ballet slippers should be worn only for dancing They, too, should be padded Children should be allowed to go barefoot only in the sand or on soft

ground, and under such conditions they should "toe in." During convalescence from any illness the feet should be supported at all times during weight-bearing because the supporting structures of the arch are relaxed. The wearing of bedroom slippers should never be permitted.

Exercises are the most important factor in the treatment. They are active and resistive, and should be carried out twice daily with the bare or stockinged feet. In the cases of adults, they are tiresome, and it is necessary to encourage persistence in their performance.

Exercises should be done slowly, and the feet should never be allowed to "come down with a bang." Tip-toe exercises are not advised. Some of the most valuable exercises are the following:

Exercises.—1. The patient stands barefooted with the feet parallel and about 2 inches apart, straddling a seam or line in a rug. On the count of one, the feet are forcibly turned out so that the weight is borne on the outer borders. On the count of two, they are allowed to roll slowly in, but not all the way. This is carried out from twenty-five to one hundred times.

2. The same as Exercise 1 except that the heels and toes are together and the two big toes are held together and on the floor.

3. Standing with the feet straddling a seam in the rug or a line on the floor, the subject walks across the room with all the weight borne on the outer borders of the feet. The big toes must be curled downward. This is carried out five times up and back across the room.

4. The same as Exercise 3 except that the subject lifts the foot so that it is opposite the other knee and walks across the room in that manner—the so-called "ostrich step." The weight must be borne at all times on the outer border of the foot.

5. The feet are held parallel and the knees maintained in a straight position. The knees are then rolled outward, which movement automatically causes the longitudinal arch to rise (Lowman). This is carried out about twenty-five times.

6. A supination board, a [illegible] shape of an [illegible]iangle about 6 inches high and 8 f[illegible] used. The [illegible]ks the length of this board three or [illegible] one would [illegible]eaves of a house.

inward and upward and holds it in this position with all his power The second person attempts to swing the foot outward and downward The effort on the part of the second person is resisted by the subject The exercise is carried out from fifteen to twenty-five times At no *time should the second person use as much power as the subject* Between each two of these exercises the subject relaxes his foot

9 In the case of older children and adults the preceding exercise can be performed as follows The right foot is turned inward and upward and held rigid while the left foot presses against it in an attempt to force it downward and outward The feet are then reversed

In cases of short heel tendons the patient may be unable to perform these exercises until the heel tendons have been stretched or operated upon

Other Exercises —Because of the foot training involved, ballet dancing is excellent exercise although at first much of it is hard on the longitudinal arch However, there are some children to whom it is detrimental before their feet have been strengthened by proper treatment Ballet dancing may be started at the age of four or five years, but toe-dancing should not be begun routinely before the age of eight or ten years

Roller skating is good, but ice skating may be *harmful* at first The child should wear a wide figure-of-8 webbing or leather strap over the stocking and a figure-of-8 leather skate strap outside of the shoe The shoes should be padded

Kiddy-cars may cause knock-knees or flat-feet if the distance from the seat to the ground is not correct for the individual child Wearing-out of the shoe on the inner border is an indication that their use is *harmful*

Support —Authorities differ on the question of support Some use metal supports exclusively, others practically never Support for the longitudinal arch can be obtained by means of beveled felt pads These afford a resilient support and thereby increase the spring of the gait They are highly desirable and are preferable to rigid supports Metal arch supports act as props or crutches and do not increase the power of the supporting structures of the foot The felt pads are inserted directly into the shoe and held by means of rubber cement (Fig 49) As they go into natural hollows, no extra space is required

A Goldthwait figure-of-8 leather strap is helpful Occasionally adhesive strapping (Fig 50) is indicated It is especially valuable in acute traumatic foot conditions Plaster-of-Paris is necessary in some cases, and is usually better than braces for short periods For severe flat-foot in children, Silver recommends the use of plaster casts over comparatively long periods in an attempt to cause a certain degree of rigidity in the varus position The braces which should be mentioned are the single outside caliper and T-strap of Jones

In cases of spasm of mild degree Freiberg straps the foot with adhesive plaster at intervals of five or six days. During such treatment it is best to forbid weight-bearing until the spasm yields. The strapping should be continued until it is possible to bring the foot into supination. Freiberg advises the injection of a few drops of a 2 per cent novocain solution into the astragalo-navicular joint. Within five or ten minutes after such an injection it is possible to bring the foot into supination and fix it in that position by strapping.

SURGERY

For cases in which peroneal spasm is too rigid to yield to these simpler measures Freiberg advocates the procedure of Robert Jones, namely, excision of a segment of the tendons of both peronei brevis and longus muscles together with subcutaneous division of the tendon of the extensor communis digitorum muscles. This should be followed by encasing the foot in a plaster cast after securing full overcorrection in supination, adduction, and dorsal flexion. Not infrequently a plastic tenotomy of the tendon of Achilles must be added.

Lengthening of the Achilles tendon is indicated in the so-called "muscle bound" foot because the patient is unable to perform the exercises properly on account of the structural shortening of the tendon.

In cases of rigid flat-foot, forcible manipulation under anesthesia, and the application of a corrective plaster cast are of great value. Occasionally, the peroneal tendons must be resected. Crushing of the external cutaneous nerve has been recommended. Osteotomy of the os calcis or other bones is occasionally indicated. Tendon transplantation is advisable in selected cases, as is also partial arthrodesis. The treatment of associated knock-knee or bow-leg in children is osteotomy and the application of corrective casts or braces.

Carr sawed through the os calcis, between the ankle joint and the attachment of the Achilles tendon and slipped the sawn portion of the bone downward $\frac{3}{4}$ inch and nailed it there with an ordinary wire nail. For moderately severe cases, Wilms recommends ankylosis of the astragalo-navicular joint to prevent slipping of the astragalus forward and inward on the calcaneus. He combines this with a wedge-shaped bone resection.

Lord and Gleich advocated an oblique osteotomy of the os calcis with inward displacement of the posterior fragment. This changes the line of weight-bearing as far inward as necessary to throw the balance of weight-bearing to the outer side of the gravity center, and causes the weight to be transmitted through the foot to its outer border, thus relieving the longitudinal arch.

Gleich exposes the calcaneus through a stirrup incision and saws obliquely through the bone from below and in front upward and

posteriorly The lower and posterior half carrying the tuberosity is then slid forward and downward The amount of correction may be increased by the additional excision of a wedge of bone with its base downward, from the anterior end of the lower fragment If the calcaneus lies in the valgus position, the posterior calcaneal fragment must be slid not only downward but also inward This may be done through a lateral incision as well as through the stirrup incision When in the desired position, the fragment is fastened with a nail

Cotton's heel-shifting operation consists in shifting the back end of the os calcis to readjust the relations of the weight-bearing line of the leg and the much discussed "*triangle of support*" of the plantar foot surface

Lowman exposes the inner edge of the calcaneo-navicular ligament The astragalo-scaphoid ligament is incised in line with the joint, and the outer end of the scaphoid denuded of its periosteum, with all ligamentous attachments The Achilles tendon is tenotomized and the foot forced upward Next, a wedge is excised chiefly at the expense of the scaphoid, but a fair piece with its base downward and inward is taken also from the head of the astragalus If the Achilles tendon is too short it is lengthened Next, if the condition is a simple, non-paralytic flat-foot with fairly strong tibials and not much overaction of the peronei, the latter are simply tenotomized The anterior tibial tendon is then isolated to its attachment and displaced with a curved instrument or blunt hook inward and downward until it slips over the squared-off corner of the scaphoid, thus passing through the opening made by the osteotomy It is not detached but its direction is altered so that, in pulling upward, it raises the scaphoid upward, assisting in forming an arch

The displaced tendon of the anterior tibial is grasped with strong forceps and held down under the scaphoid while the operator places a deep suture of fine kangaroo tendon into the middle of the calcaneo-navicular ligament under the gap of the osteotomy opening Next, this is brought up and passed around the anterior tibial tendon the assistant making strong correction of the arch while it is tied This position is maintained while two chromic sutures are placed through the margin of the cut astragalo-scaphoid ligament laterally When these are closely approximated or imbricated, the foot remains in good position

Young raises the arch by lengthening the tendo Achillis and reinforces the posterior tibial muscle by changing the course of the anterior tibial tendon He reinforces the plantar navicular-cuneiform and medial first tarso-metatarsal ligaments He does this by drilling a hole and making a slot in the navicular bone into which he transplants the anterior tibial tendon (Fig 106)

His technic is as follows:

A drill hole 6 or 7 mm. in diameter is made vertically through the navicular bone lateral to the tuberosity from the superior to the inferior surface. The superior opening of the drill hole is made in a "U" shape with a gigli saw and very thin chisel, in the posterior part of the medial surface of the navicular tuberosity. A small gouge is used to make a groove on the inferior surfaces of the first cuneiform and the navicular bones, from the insertion of the tibialis anterior muscle to the drill hole.

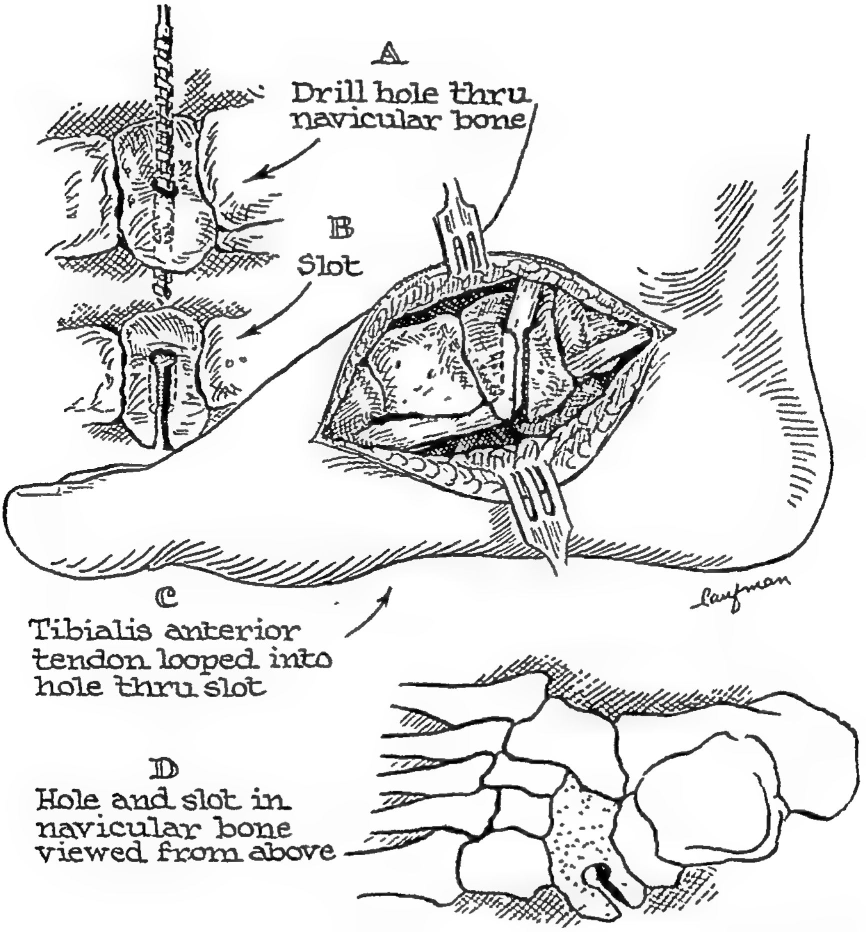


Fig. 106.—Young operation for flat-foot. (Young, courtesy of Surg., Gynec. and Obst.)

The sheath of the tibialis anterior tendon is exposed and incised in its distal 6 or 8 cm. After the tendon is freed down to its insertion it is pulled posteriorly with a button-hook and thrust through the slot in the navicular bone to a position so that it enters the drill hole and lies in the groove in the inferior surfaces of the navicular and the first cuneiform bones. The tendon of the tibialis posterior is replaced as near as possible to its original position.

The extremity is immobilized with a plaster cast The ankle is fixed in its limit of dorsiflexion and the knee in 20 degrees of flexion

Perthes excised a wedge from the lower and inner surface of the navicular with the base of the wedge below and medial He then split the anterior portion of the calcaneus by osteotomy and inserted the wedge from the navicular The peroneal tendons are lengthened first White has improved upon this operation

Miller s operation consists in making a rectangular osteoperiosteal-fascial flap in the region of the first cuneiform, the scaphoid, and the calcaneus, performing an arthrodesis of these joints, and replacing the flap (Fig 107)

The incision is made along the inner side of the tarsus and the mediotarsus from behind From a point over the os calcis, it is extended forward over the bodies of the scaphoid and internal cuneiform bones and is ended at the base of the first metatarsal It opens directly down on the spread of the calcaneo-scaphoid ligament and the insertions of the posterior and anterior tibial tendons

After the subcutaneous fascia and fat are dissected up, a sharp chisel or osteotome is taken and the fanned-out insertion of the calcaneo-scaphoid ligament and posterior tibial tendon is lifted on a thin slab of bone from its attachment to the sides of the scaphoid and internal cuneiform bones and held back with a retractor This exposes the joints between the astragalus and scaphoid, scaphoid and internal cuneiform, and internal cuneiform and the base of the first metatarsal bones The lesser articular ligaments are lifted upward and downward, subperiosteally, and preserved as well as possible to be re-applied over the area of fusion The articular surfaces from between the scaphoid and internal cuneiform, and the internal cuneiform and the head of first metatarsal are lifted out with a thin osteotome At the same time, the Achilles tendon is lengthened In some cases the neck of the astragalus can be shortened by taking out a section with the osteotome The head can then be transplanted toward the middle of the foot When the articular surfaces are removed, the forefoot can be brought into adduction and the first metatarsal rotates to a corrected position The foot is then held in adduction, and the slab of bone holding the insertion of the calcaneo-scaphoid ligament and posterior tibial tendon is pulled forward on tension and transplanted as a graft to the body of the internal cuneiform bone and the base of the first metatarsal The whole mass passes forward beneath the anterior tibial tendon which is not disturbed at its insertion The wound is closed layer by layer, chromic catgut being used beneath and silk in the skin

In this procedure the scaphoid, internal cuneiform, and the base of the first metatarsal fuse to maintain their corrected relations The broad insertions of the calcaneo-scaphoid ligament and posterior

tibial tendon have their slack taken up as they are transplanted forward, and form a substantial thickened sling to keep the head of the astragalus directed into the normal weight-bearing lines of the foot.

After the operation the foot is left in plaster for six weeks and then put into an adducting shoe with a Thomas heel. After a short period of foot exercises and massage, supervised weight-bearing is begun.

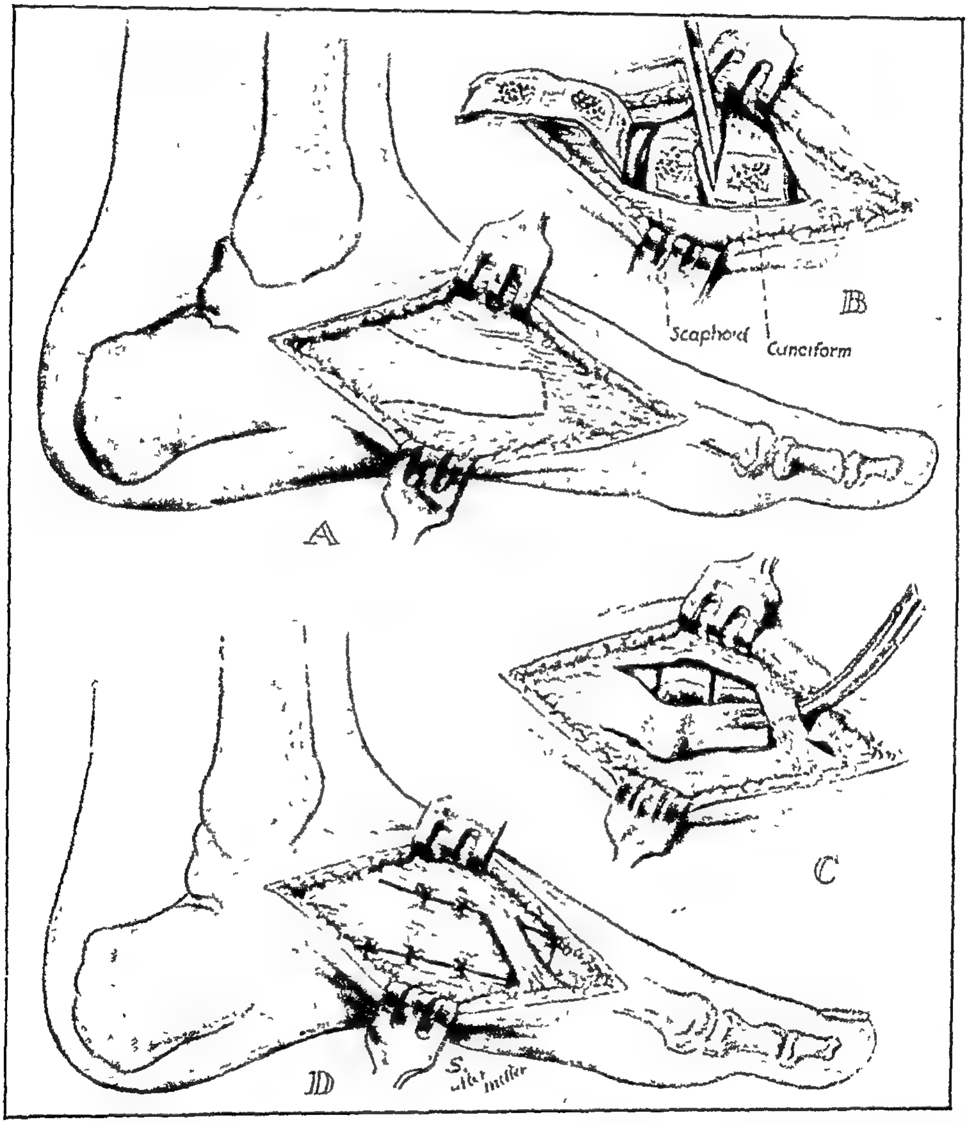


FIG 107.—Miller operation for pes planus. *A*, Exposure on medial side of foot Flap of fascia outlined and dissected free with small segment of bone from scaphoid and internal cuneiform bones *B*, Cartilage excised from articulations of scaphoid and internal cuneiform bones and base of first metatarsal and internal cuneiform bones. Insertion of tibialis anticus tendon is not disturbed. Arch restored by rotating and adducting forefoot. *C*, Small segment of bone lifted with periosteum from side of first metatarsal; fascial sling and small segment of bone brought forward beneath tibialis anticus, to be stitched under tension to side of first metatarsal bone Segments of bone on flap should lie across joint spaces to act as grafts. *D*, Fascia sutured in place, maintaining a normal arch line (Redrawn from Miller: Jour. Bone and Joint Surg : Campbell's Operative Orthopedics, courtesy of the C. V. Mosby Company)

The operation which Clark calls a "rebalancing operation for pronated feet" consists of the removal of a wedge from the mesial inferior aspect of the astragalus together with an osteotomy of the neck of the astragalus, which permits correction of badly pronated feet without arthrodesis of any joints

Hoke Operation —Hoke described an operation for the correction of extremely relaxed feet, the type that are very flat, elongated, badly pronated, moderately abducted, and extremely flexible in the mid-tarsal joints and metatarsotarsal joints (Fig 109) The flexibility

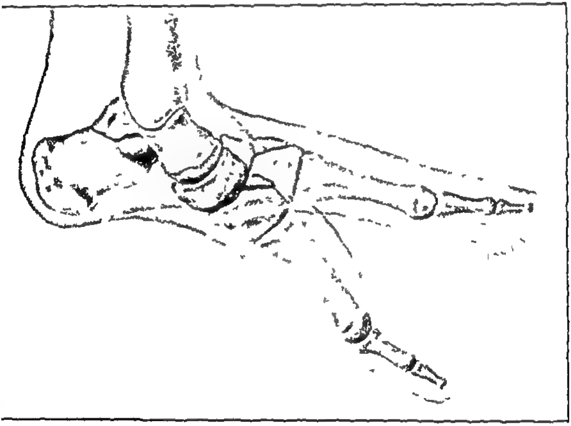


Fig 108 —Composite view of bones before and after correction of equinus
(Courtesy of Dr Michael Hoke)

is greatest at the scaphoid cuneiform and internal middle cuneiform joints This is of paramount importance because it interferes with the coordinated arch-lifting power of the tibialis posticus, tibialis anticus, and flexor hallucis longus Hoke states that there can be no mechanical substitute for the power of these three muscles In order to hold up the arch, these three muscles must be tightened simultaneously the instant the foot strikes the ground in walking If this does not occur the astragalus tilts downward (equinus astragalus), and throws all of the strain upon the mid-tarsal segments of the foot The ligaments become stretched more and more, and ultimately the joints are too loose for the muscle power to be effective

Another important factor which completes the vicious circle in the development of the flexible flat-foot is the shortness of the Achilles tendon. The conditions of greatest importance in such a foot are: (1) a short Achilles tendon; (2) extreme flexibility of the mid-tarsal joint, especially the scaphoid, cuneiform, and internal middle cuneiform joints; and (3) the relation in position of the bones as shown by a lateral roentgenogram of the foot. The operative corrective steps, therefore, are these: (1) the Achilles tendon is lengthened; (2) with

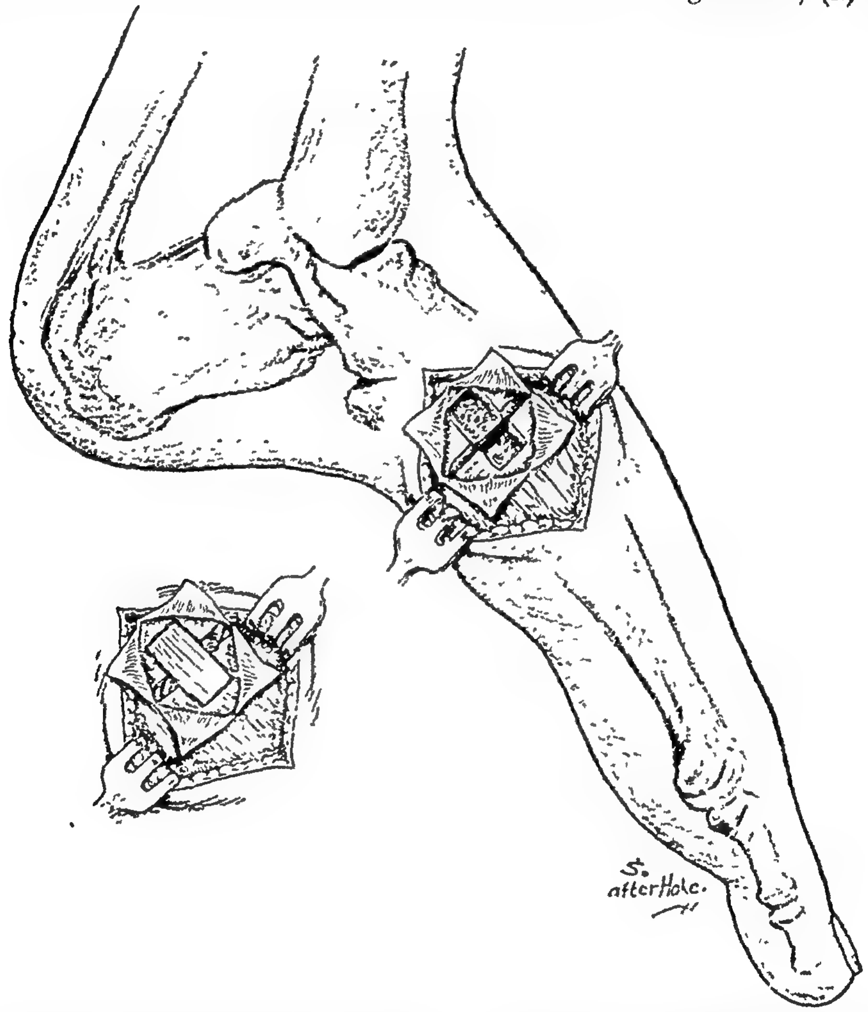


FIG. 109.—Operation of Hoke for pes planus. Tendo Achillis lengthened (not shown in illustration). Medial incision exposing scaphocuneiform joint. Cartilaginous surfaces removed from scaphoid and middle and internal cuneiform bones. Arch restored by forcing anterior end of first metatarsal bone into equinus Small rectangular segment of bone removed from across scaphocuneiform joint. Insert shows cortical graft of equal dimension countersunk into defect (Redrawn from Hoke: Jour Bone and Joint Surg.; Campbell's Operative Orthopedics, courtesy of the C. V. Mosby Company.)

the foot in equinus, the scaphoid, internal and middle cuneiform joints are stiffened by bone grafting; (3) a careful setting after the manner described below. The skeleton is thus restored to normal, and thereafter the muscles, when trained, hold up the arch without hindrance.

The technic is as follows As the first step in the procedure, the tendo Achillis is lengthened and the skin sutured A second incision is then made along the medial border of the foot, exposing the scapho-cuneiform joint, and the cartilaginous articular surfaces are excised from the scaphoid and internal and middle cuneiform bones The foot and anterior end of the first metatarsal bone are forced into equinus and so maintained while a rectangular block of bone is resected

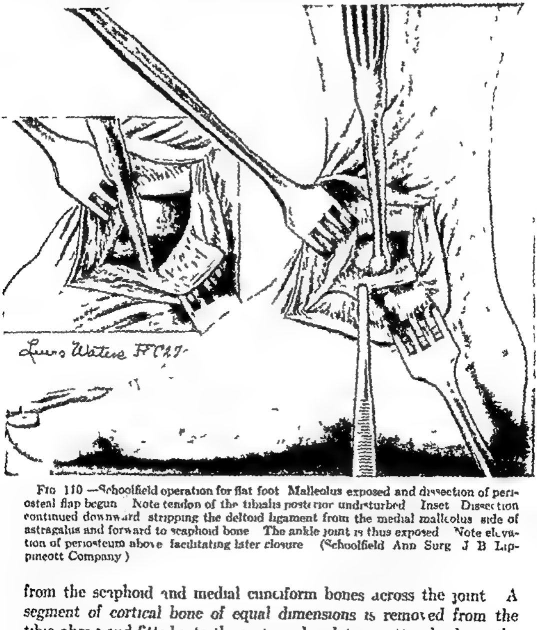


FIG 110 —Schoolfield operation for flat foot Malleolus exposed and dissection of periosteal flap begun Note tendon of the tibialis posterior undisturbed Inset Dissection continued downward stripping the deltoid ligament from the medial malleolus side of astragalus and forward to scaphoid bone The ankle joint is thus exposed Note elevation of periosteum above facilitating later closure (Schoolfield Ann Surg J B Lippincott Company)

from the scaphoid and medial cuneiform bones across the joint A *segment of cortical bone of equal dimensions* is removed from the tibia above and fitted into the rectangular slot or gutter, bridging the joint Small fragments of bone are packed into the unfilled spaces, and periosteal flaps are closed over the graft

A cast is applied in two sections, the first part encasing only the foot With the foot and anterior end of the first metatarsal bone in

equinus and the heel inverted, a plaster reinforcement is applied, being well molded under the scaphocuneiform joint. After the plaster has set, the ankle is dorsiflexed to a 90 degree angle with the leg and knee immobilized by a cast. Two weeks postoperatively this cast is removed and the foot is further immobilized in an ordinary boot cast for a period of six weeks. Massage is then given for a few days, and walking is resumed with the aid of a metal arch support. Two weeks after the operation, the cast, dressings and skin sutures are removed.

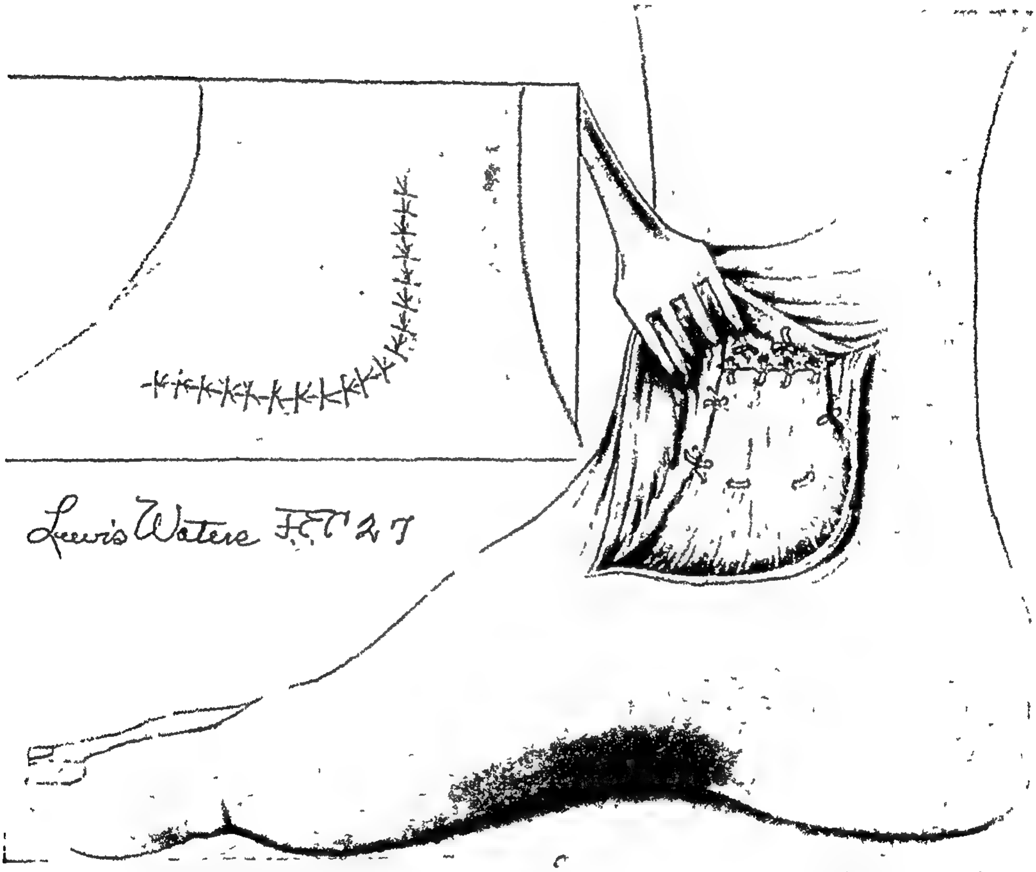


FIG. 111 —Schoolfield operation for flat-foot. The foot is held in marked varus, the periosteal-ligamentous flap drawn tautly upward and sufficiently excised above to take up the slack. Sutures have been put in Note "stay" sutures of mattress type. Inset: Skin incision as closed (Schoolfield, Ann. Surg, J. B. Lippincott Company.)

The foot bones maintain their position, and a cast is applied from toes to tibial tubercle. This is removed after six weeks. Massage is given for a few days. A foot plate is applied, fitting well under the scapho-cuneiform joint. Wide-toed shoes are put on. The patient begins to walk with crutches. Massage is continued, and for two weeks the patient is drilled to contract the tibialis posticus, tibialis anticus, and the flexor hallucis longus the instant the foot touches the ground when walking. It is continued for two or three months. The plate

is then removed and shoes put on that do not restrict the free use of the toes

Kidner Operation.—For the correction of certain cases of intractable flat-foot, Kidner recommended removal of the prehallux or accessory scaphoid and transplantation of the posterior tibial tendon.

Removal of the accessory scaphoid at the time of the operation, is indicated. If the accessory scaphoid has become fused with the scaphoid itself, removal of the bony overgrowth is indicated. In addition, the tendon of the tibialis posticus should be shortened.

Badgley believes the accessory scaphoid is a possible cause of rigid flat-foot which should be differentiated from the ordinary type. The usual routine roentgenogram does not sufficiently demonstrate the deformity. The direction of the ray should be oblique to the foot. The abnormal formation of the bone is then clearly shown. There is frequently a bony overgrowth on the caput tali associated with coalition that may lead to an erroneous diagnosis of arthritis as the cause of the disability. The appearance of symptoms at the age of puberty is a striking factor in the clinically reported cases.

The failure of the customary forms of treatment for rigid flat-foot with peroneal spasm in this type of case suggests the need for more radical therapy. Lengthening of the peroneal group has proved to be of no value in Badgley's cases. Resection of the bony bridge may give a mobile functional foot. In further advanced cases arthrodesis of the subastragalar, calcaneo-navicular and calcaneo-cuboid joints may be necessary. In most cases the usual procedures employed for rigid flat-foot of the primary soft-tissue type will not be effective.

Wagoner reported a case of bilateral congenital fusion of the calcanei and cuboids which he believed was due to the congenital absence of the calcaneo-cuboid articular cartilages.

Operation is indicated in the conditions that resist conservative treatment. For the complete fusion type seen soon after the onset of symptoms Badgley recommends resection of the fused area. In cases first seen after considerable delay, it is probable that traumatic changes in the subastragalar and calcaneo-navicular joints have developed and arthrodesis will be required to relieve the symptoms.

The condition known as "rocker foot" in which the normal longitudinal arch is completely inverted and the patient walks as though on a rocker, is a serious disability and as a rule requires operation. Operative correction may include wedge-shaped resection of bone from the sole of the foot.

In operating for flat-feet, you can give the patient any height arch you desire. I warn you against giving him too high an arch.

Milch Operation.—To simulate the action of the deltoid ligament, to elevate and invert the os calcis, Milch devised the following opera-

tive procedure. Under a tourniquet placed around the calf, a curved incision is made, extending from the scaphoid tubercle backward around the tip of the internal malleolus and then upward to a point about 3 inches above the malleolar tip. At a point sufficiently above the epiphyseal line, to prevent injury to the growing zone, the medial surface of the tibia is subperiosteally exposed. A tunnel, running

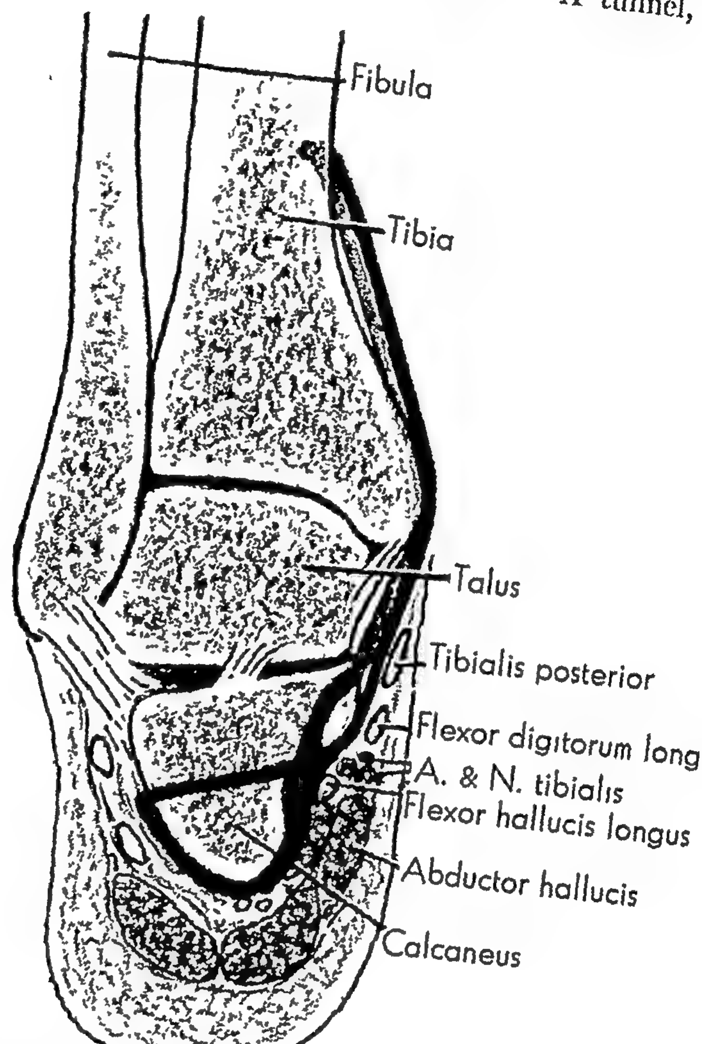


FIG. 112.—Sagittal section.—The heavily shaded
(Milch

caneocuboid articulation are elevated, and a transverse calcaneal tunnel is drilled, so as to emerge on the lateral surface of the os calcis, in the region of the trochlear process. The guide suture previously passed through the tibia is now passed down along the inner aspect of the ankle, beneath the tendon of the tibialis posticus muscle, and around the inferior surface of os calcis. A small external counter incision is made, and from without inward the graft is passed back through the tunnel made in the calcaneus.

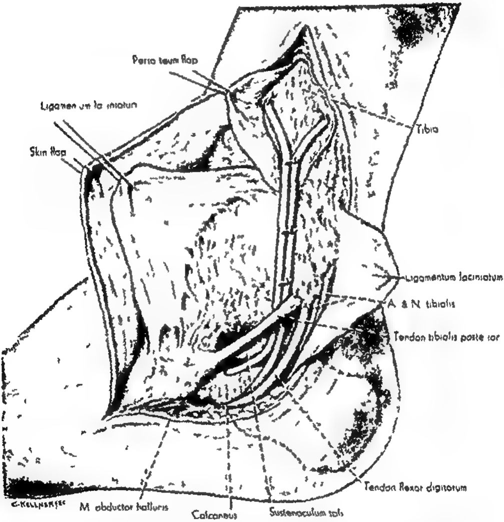


Fig 113.—The fascial graft in situ seen from the medial aspect. When sufficient graft cannot be obtained the anterior ascending arm may be dispensed with. (Milch courtesy of Surg Gynec and Obst.)

With the fascial stripper, a long strip of fascia is removed subcutaneously and is passed through the drill holes, exactly along the course of the guide sutures. The heel is strongly supinated and the strands of the fascial graft are sutured to the bone and are then united to each other, if possible. The wound is closed in layers and a plaster-of-Paris boot is applied with the foot in the maximum of inversion

tive procedure. Under a tourniquet placed around the calf, a curved incision is made, extending from the scaphoid tubercle backward around the tip of the internal malleolus and then upward to a point about 3 inches above the malleolar tip. At a point sufficiently above the epiphyseal line, to prevent injury to the growing zone, the medial surface of the tibia is subperiosteally exposed. A tunnel, running

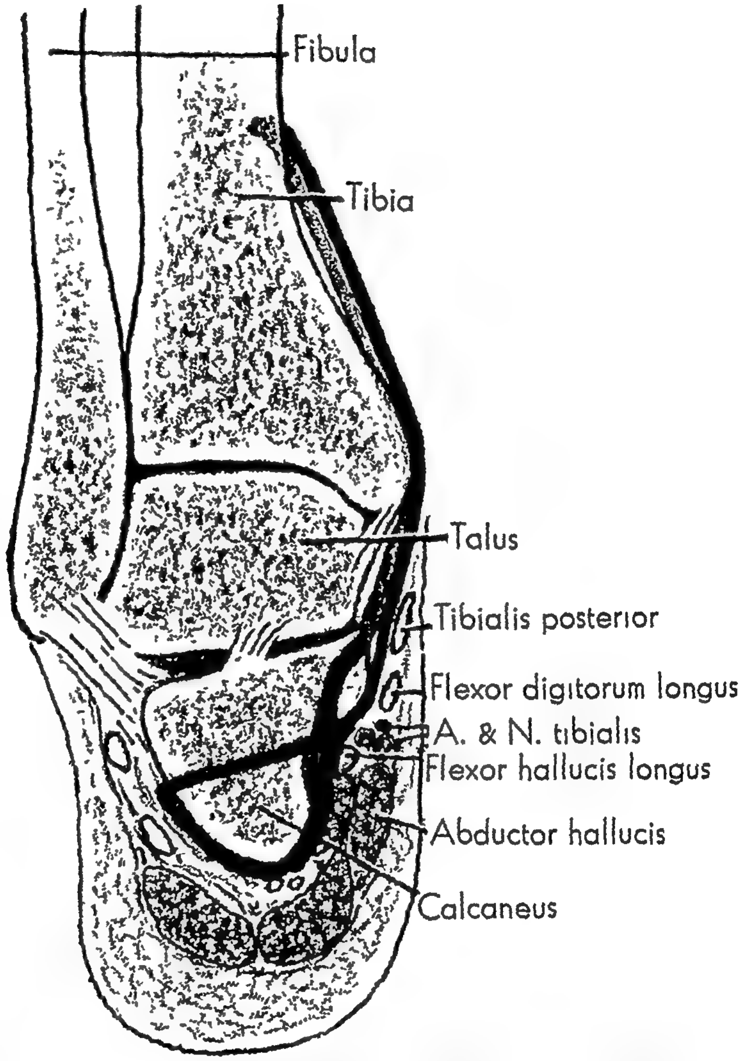


FIG. 112 —Sagittal section.—The heavily shaded line indicates the fascial graft (Milch, courtesy of Surg Gynec and Obst.)

antero-posteriorly, is made, beginning on the medial surface of the tibia, above the epiphyseal line. Through this, a guide suture is passed. The incision is opened so as to expose the abductor hallucis below and the tendon of the tibialis posticus in front. The sustentaculum tali is visualized between the tendons of the tibialis posticus and the flexor longus digitorum muscles. With a broad, blunt, periosteal elevator, all the tissues lying below the sustentaculum and posterior to the cal-

caneocuboid articulation are elevated, and a transverse calcaneal tunnel is drilled, so as to emerge on the lateral surface of the os calcis, in the region of the trochlear process The guide suture previously passed through the tibia is now passed down along the inner aspect of the ankle, beneath the tendon of the tibialis posticus muscle, and around the inferior surface of os calcis A small external counter incision is made, and from without inward the graft is passed back through the tunnel made in the calcaneus

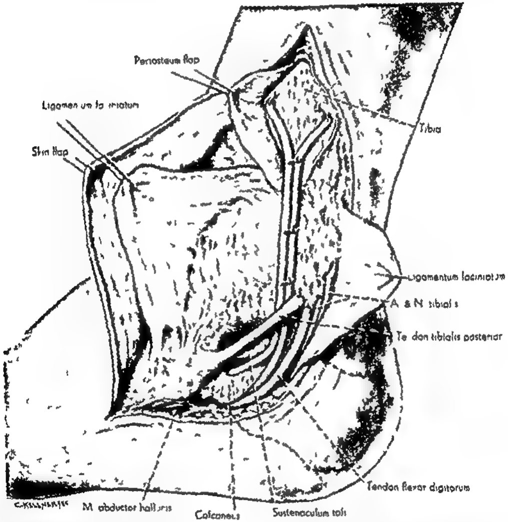


Fig 113 —The fascial graft *in situ* seen from the medial aspect When sufficient graft cannot be obtained the anterior ascending arm may be dispensed with (Milch courtesy of Surg Gynec and Obst)

With the fascial stripper, a long strip of fascia is removed subcutaneously and is passed through the drill holes, exactly along the course of the guide sutures The heel is strongly supinated and the strands of the fascial graft are sutured to the bone and are then united to each other, if possible The wound is closed in layers and a plaster-of-Paris boot is applied with the foot in the maximum of inversion

Immobilization is maintained for a period of 6 weeks. Upon removal of the plaster, a well molded foot plate is prepared and patient is allowed to bear weight in wedged shoes. The operation is intended solely for those cases in which excessive pronation has resulted from a loss of the restraining action of the deltoid ligament. It should not be employed when the pronation is caused by bony deformity. A valgus defect due to a malunited fracture of the lower end of the tibia is not amenable to correction by this procedure. It is essential, therefore, to determine by roentgenograms of the ankle joint, that (1) the plane of the articular surface of the tibia is perpendicular to long axis of the bone; (2) the astragalus is held in its normal position by a well developed ankle mortise; and (3) there is no abnormality in the os calcis. If these facts can be established, the pronation may be attributed to a loss of deltoid ligament support.

The Rigid Painful Flat-foot

Rigid painful flat-feet cause serious disability. I have seen persons with 2 artificial limbs walk more gracefully than others with rigid flat-feet. The ability to actively supinate the foot constitutes The Great Divide, between a major and a minor situation.

Rigid flat-feet are very difficult to treat. They entail a long period of disability. The prognosis is always guarded.

Non-operative Treatment Consists of:

1. Absolute rest in bed, preferably in a hospital.
2. The application of an anodyne lotion.
3. Hot fomentations.
4. Manipulation under intravenous anesthesia (either pentothal-sodium or morphine) or local anesthesia.
5. Application of a plaster-of-Paris cast maintaining varus position and crutches.
6. Massage.
7. Whirlpool.
8. Exercises.
9. Special shoes with modifications without and within.
10. Arch support.

Operative Procedures are Based Upon:

1. Tenotomy of peroneal tendons.
2. Operations for flat-foot.
3. Subastragalar arthrodesis

CHAPTER VII

STATIC DEFECTS AND DEFORMITIES (*Continued*)

DISTURBANCES OF THE METATARSAL ARCH

The Forefoot Anatomy—Biomechanics.—The forefoot is composed of a set of five individual levers, each formed by a metatarsal bone and its associated tarsal bones, and having its fulcrum situated in the metatarsal head (Lambrinudi). In the case of the first segment, when the foot swings upwards as a step is taken, Jack describes the metatarsal as moving about a fixed axis situated in the centre of the head. The short flexor incorporating the sesamoids passes directly below the head of the first metatarsal, and is angulated by it. During the upward swing, the muscle gains in tone as it becomes stretched ready for the "take-off," and at the same time the angulation increases. The effect of this action is the fixation of the first phalanx of the toe firmly to the ground, and also, owing to the angulation, the exertion of pressure on the metatarsal head in an upward and forward direction. This upward pressure is normally opposed by the body weight transmitted down through the metatarsal. A triangle of forces is thus constituted, which acts on a point if the metatarsal head is fixed.

The axis of weight-bearing is situated along the third metatarsal at the beginning of a step and gradually moves medially as the heel is raised, until just before the "take-off" when it lies midway between the first and second metatarsals. If the first segment is incompetent, all the weight on the medial side of the axis is borne by the second metatarsal alone, provided it can withstand the strain, and no weight can be transmitted through the first segment until the axis has moved to the medial side of the second metatarsal. During the first stage of a step, therefore, the upward thrust of the short flexor is unopposed, with the result that instead of rotating normally, the head tends to ride forwards and upwards against the rim of the first phalanx, until the metatarsal assumes a sufficiently vertical position to drive it back again.

The metatarsal arch is the dome-shaped structure seen on the side or oblique view of the skeleton extending from the tarso-metatarsal articulations to the metatarso-phalangeal joints. Considered from the mechanical point of view, it is curved in two directions, laterally and antero-posteriorly. What is usually referred to as the metatarsal

arch is the structure formed by the metatarsal heads, *i. e.*, the true transverse arch.

The skeletal parts consist of the metatarsal bases, shafts, and heads. The proximal phalanges and sesamoids are accessory structures often involved in metatarsal disturbances. The metatarso-phalangeal joints are ball-and-socket joints surrounded by capsules lined with synovial membranes. Like other joints, they are subject to stress, strain, injury, growth disturbances, and infections. The muscles of this region are the plantar and dorsal interossei, the lumbricales, and the adductor hallucis. The tendons are the flexors and extensors of the toes, the abductors and adductors, and the peroneus longus. The plantar fascia is an important structure. The interdigital vessels and nerves often demand special consideration. Between the metatarsal heads there are bursæ. The skin of the plantar surface is unusually thick.

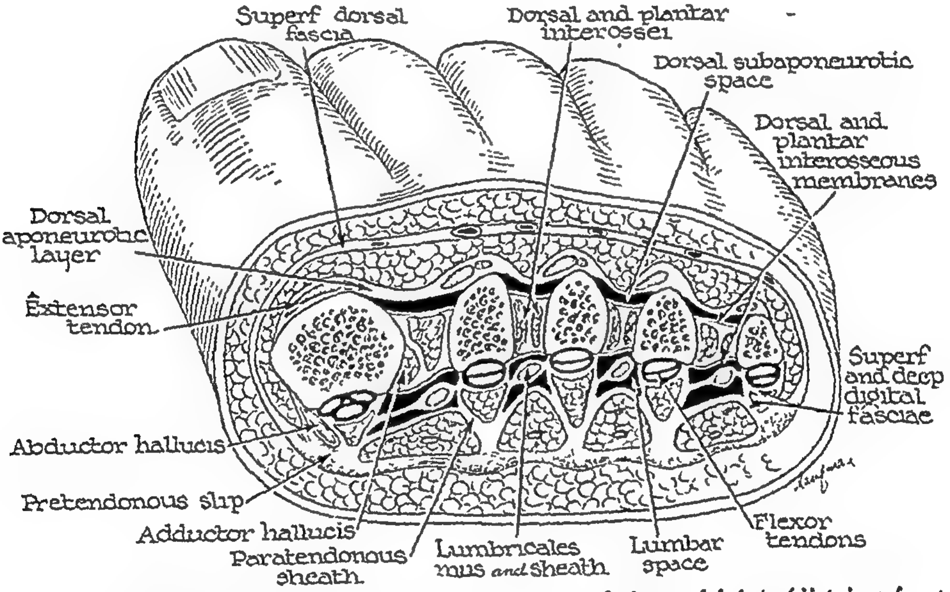


FIG 114.—Cross-section just proximal to the metatarsophalangeal joints (distal surface) (Redrawn from Grodinsky, courtesy of Surg. Gynec. and Obst.)

The chief functions of the regions are t tability in locomotion, to give spring ce to the st relieve the spine and central nervou jars. The arch is highest near the tarso-metat nd gradua lower toward the metatarsal heads rotects t essels,

When the transverse arch is properly maintained the anterior pillar of the longitudinal arch rests only on the heads of the first and fourth metatarsal bones, that of the fifth often presses also on the ground, especially when more weight is borne on the foot If the transverse arch yields, the heads of the intervening metatarsal bones receive undue pressure, and periostitis and callosities develop under them The lumbricales and interossei muscles fix the toes to the ground in walking and are important sustainers of the arch When these groups of muscles are paralyzed or weakened, the toes assume a position of "claw-toe" and the normal gait is disturbed When the toes are forced to assume a position of clawing by any cause, such as improper

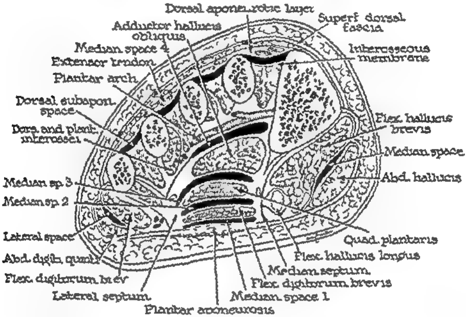


FIG 115 —Cross section of foot at level of the middle of the fifth metatarsal bone (proximal surface) (Redrawn from Grodinsky courtesy of Surg Gynec and Obst)

shoes, these two groups of muscles are unable to function properly The unopposed action of the extensor muscles aggravates the clawing and forces the metatarsal heads to assume a *depressed position* The transverse head of the adductor hallucis approximates all of the toes, thereby increasing the curve of the transverse arch

Morton believes that the term "anterior metatarsal arch" is anatomically incorrect In support of this belief he states that, although, in the passive foot, the ball assumes transversely a more or less concave form, in a weight-bearing foot the heads of all the metatarsal bones lie in a single horizontal plane, each one having direct contact with the ground or supporting surface In other words, no real arched conformation is maintained in this part

He states that the clinical word "metatarsalgia" is commonly used interchangeably with the term "depressed anterior arches," but since the heads of the metatarsal bones lie on the same horizontal plane in their functional relationship and the supporting surfaces are usually solid, there can be no actual depression of the middle ones.

The causes of metatarsal arch disturbances are heredity, static defects, occupational injuries, obesity, infections, glandular disturbances, toxic factors, and pregnancy. The treatment includes rest, local applications, proper shoes, internal and external modifications of the shoes, support, exercises, massage, and contrast sprays. Operations include closed manipulation and open operations on the bones and soft tissues.

Etiology.—Although very common in adults, metatarsalgia is comparatively infrequent in children. In childhood it is often due to osteochondritis, a condition described by Freiberg as "infraction of the metatarsal head." I have treated 20 cases. The cause is thought to be trauma to growing epiphyses which interferes with the local circulation and growth and results in aseptic necrosis.

Metatarsal troubles are more common in the female than the male, undoubtedly because females more frequently wear improper or incorrectly fitted shoes. Short stockings and the forceful pulling of stockings are other factors. Heredity may be important, especially in cases of arthritis and pes cavus.

Arthritis is an important cause of metatarsalgia. In a fair share of arthritic cases infections of various types are responsible. The infection may be local or secondary to foci in the teeth, tonsils, sinuses, or abdominal or pelvic structures. Obesity or toxemia, such as toxemia due to pregnancy or an infection such as influenza, may be a causative factor. Static disturbances due to prolonged standing on hard floors predispose to metatarsal disturbances. Traumas of various sorts are important. Among these are the sprain or strain causing the "chauffeur foot" and the "dancer's foot." Injury from falling objects or being stepped on may produce metatarsalgia.

In some cases the cause is inflammation of the metatarsal bursæ. Roberts describes a type of bursitis which gives rise to a disabling soreness sometimes confined to the ball of the foot, sometimes extending upward and backward, and sometimes accompanied by puffiness of the adjacent soft tissues. The pain subsides when the foot is at rest and recurs when standing or walking are resumed. Acute twinges of pain are produced by stepping on uneven surfaces such as cobble stones or street car tracks because sudden pressure is brought upon the distended sacs. Royle also described metatarsal bursitis. Hertzler

reminds us that in the region of the metatarsophalangeal articulation there are *three sets of bursæ* (1) *the intertarso-phalangeal bursæ*, (2) the bursæ below the heads of the metatarsal bones, and (3) the bursæ about the tendons in this region He calls attention to the fact that in the removal of the metatarsal head the bursa lying beside it is also removed He believes that removal of the bursæ might effect a cure

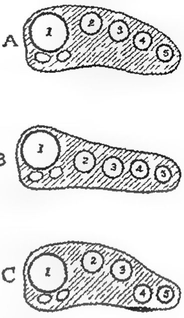


Fig 116 —Schematic representation of metatarsal arch *A* Normal position of metatarsal heads and sesamoid bones *B* Depressed metatarsal arch *C*, Depression of fourth metatarsal head *with production of callosity*

I have seen a patient who developed metatarsalgia following a gunshot amputation of all her toes I have also seen a surgeon who had metatarsalgia following a septic infection of the metatarsal region due to the piercing of his shoe by an infected scalpel Amputations, bunion operations, and hammer-toe operations are frequently followed by metatarsalgia Often it is present but unrecognized before the operation Fractures, dislocations, and thermal and chemical burns *may result in metatarsalgia* Other causes are spastic paralysis, plantar fasciitis, paralgia hyperesthetica, pes cavus independent of, or coincident with spina bifida, circulatory lesions such as endarteritis, thrombo-angiitis obliterans, and Raynaud's disease, causalgia, frost bite, chilblains, trench foot, and soft corns I have seen several cases of incomplete amputation of the toes which resulted in metatarsalgia

I wish to call attention to a new cause of metatarsalgia which I believe is very common and has been entirely overlooked Short-legged persons who sit at desks or card tables are prone to sit with their heels off the floor and toes turned up like the ballet dancer who is in the "half-toe" position They thump or press on the tips or balls of the toes This exaggerates the depression of the metatarsal arch and the strain on the heads of the metatarsals, the phalanges, capsules of the joints, and the ligaments, tendons, and muscles I have noted this habit in the cases of doctors, lawyers, professional artists, stenographers, and even orthopædic surgeons Moreover, it is not limited to short-legged persons I have observed it at games, at sporting events, at meals, and during periods of relaxation When it is called to the attention of the person, he realizes how frequently and for what long periods he has been sitting in this position No

amount of treatment with shoes, pads, bars, crescents, exercises, massage, sprays, or physical therapy can undo the damage done over these long and short periods of improper sitting posture.

In 1931 Betts reported about 25 cases of fibroneuroma of a plantar nerve or Morton's toe. In 1943 McElvenny stated he believed that Morton's toe is caused by a tumor involving the lateral branch of the medial plantar nerve. Careful palpation will usually reveal the tumor which lies high in the web between the third and fourth toes. He advises excision of the tumor in those cases where symptoms justify radical treatment. Young and Dockerty have done some excellent work on this subject. It is surprising to see the size of the nerve and the tumor.

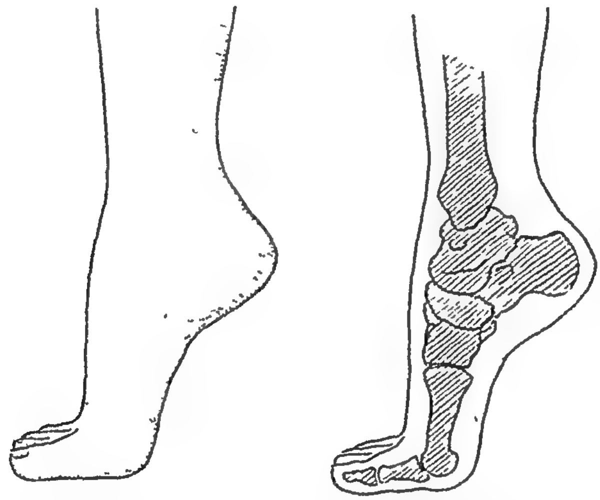


FIG. 117.—Position of a foot in equinus with dorsiflexion of the toes

Note the tremendous strain thrown on the head of the metatarsal. This is a common position assumed in sitting at one's desk, at the dining table and at the card table. It is the cause of much metatarsal pain.

Pathology.—Depression or inversion of the arch which is normally convex causes pressure on the interdigital nerves and relaxation of the capsules and ligaments. Periostitis of the metatarsal bone may be found. Bursitis has been described above. Papillomas and soft corns, usually between the fourth and fifth toes, are common. The infectious factor is similar to that in any other joint.

Symptoms.—The symptoms of metatarsal depression are pain and rigidity, and at times spasm and contractures of the extensor muscles. The physical conditions of metatarsal depression are inversion of the arch, callus formation, and sensitiveness and tenderness which may be due to periostitis of the metatarsal bones. Every schoolboy knows that if he can grasp another boy's hand, depress the knuckles, and exert lateral compression, he can cause pain. An analogous condition is found in a depressed metatarsal arch. The term "metatarsalgia"

means pain in the metatarsal region It does not describe the pathological condition

Diagnosis —Anteroposterior and lateral roentgenograms are always desirable although a good history and careful examination are usually more valuable The film may reveal the depression, bunions, "bunionettes" (exostoses of the fifth metatarsal heads), the position and condition of the sesamoids, and occasionally a metatarsophalangeal osteochondritis

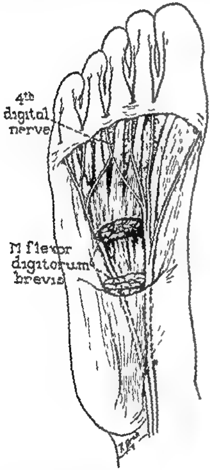


FIG 118

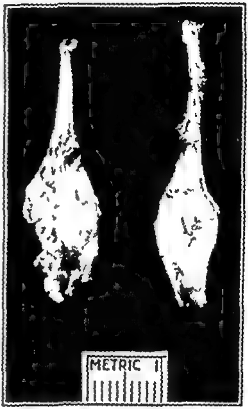


FIG 119

FIG 118 —Diagram from actual dissection showing dual derivation of the 4th digital plantar nerve Note the transverse sling across the belly of the flexor brevis muscle anchoring of the nerve resulting from this anatomic relation is supposed to lead to neuroma (Courtesy of M B Dockerty)

FIG 119 —Bilateral sclerosing neuroma showing fusiform enlargement of plantar digital nerves Morton s toe (Courtesy of M B Dockerty)

Prognosis —The prognosis depends upon the pathological condition and the cooperation of the patient in carrying out the treatment

Treatment —The treatment of the usual type of metatarsalgia consists of local and general measures The latter are the removal of foci of infection and the correction of metabolic, hygienic, and dietetic disturbances The local treatment consists of the relief of inflamma-

FIG 120.—Heavy elastic metatarsal cuff A felt pad may be inserted underneath.

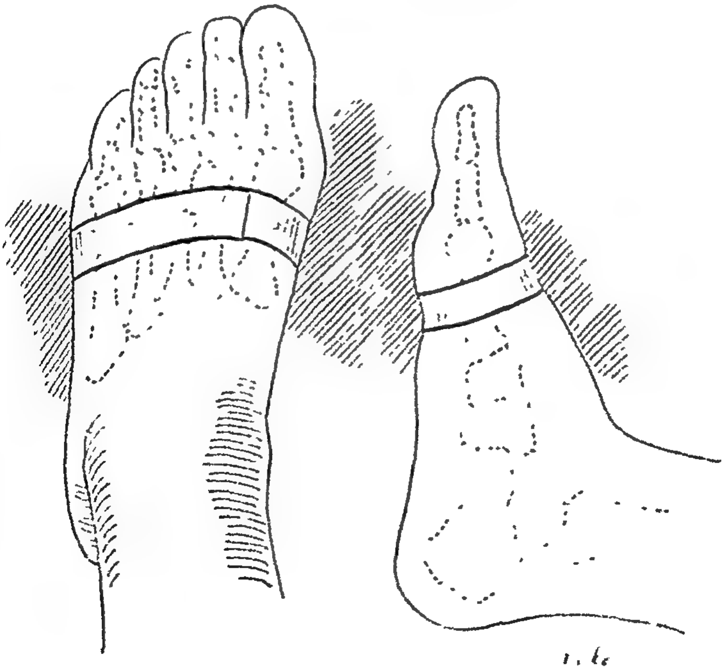


FIG. 121.—Adhesive strapping of metatarsal region. Note that the adhesive is behind the heads of the first and fifth metatarsals.

tion or irritation, proper shoes and shoeing, metatarsal support, and physiological restoration of the power of the supporting structure of the arch Irritation and inflammation may be relieved by rest and relief from weight-bearing In severe cases, rest in bed with the application of an anodyne lotion in conjunction with fomentations and elevation of the feet is indicated

The shoes should have a straight last, a round toe, a shank of medium width, and a heel of moderate height The flexibility or rigidity of the shank depends upon whether there is an accompanying disturbance of the longitudinal arch The fitting of the shoe is very important Custom-made shoes are often too short The shoe should be modified by the addition of an anterior metatarsal bar, crescent, or notched, tilted rubber crescent (Fig 42)

Properly shaped and bevelled felt or rubber pads should be inserted in the shoe to support the depressed structures Temporarily this pad may be applied directly to the foot and secured by means of a resinous glue and strips of adhesive plaster or by means of a simple elastic metatarsal cuff which aids in supporting the arch laterally By some a laced leather cuff is preferred An adhesive plaster compression band around the waist of the foot often affords considerable temporary relief (Fig 121)

The felt pad is usually inserted directly into the shoe and secured by means of glue An insole is not essential Because it is not physiological to compress the delicate foot muscles between the rigid bones above and a rigid object below, I practically never use a metal plate to support a depressed metatarsal arch, usually depending entirely on the resilient support of the felt pad Sponge rubber may be employed The patient's hose should be long enough, and must not be drawn too tightly Massage of the feet twice daily with an anodyne ointment is beneficial Contrast foot baths have a valuable tonic effect upon the feet

Directions for Massaging the Feet —The feet should be massaged for five minutes every morning and night It is desirable that the massaging be done by another person, with the patient lying down A deep rotatory movement should be used Rubbing should be avoided

Exercises —Special exercises are of the greatest value in increasing the power of the supporting structures and the flexibility of the metatarsal arch Each exercise should be done with the bare feet twice daily

1 *Door-stop Exercise* —Two old-fashioned door stops obtainable at a hardware store are prepared for use by removing the rubber tips with a pair of nippers They are then screwed into a board about 14 inches long, 8 inches wide, and 2 inches thick The centers of the door stops should be 6 inches apart A heel rest the same height as

the door stops ($2\frac{3}{8}$ inches) is added. The board is placed on the floor and the patient sits on a chair in front of it. Each foot is placed with the heel on the heel rest and the metatarsal arch on a door stop with very slight pressure just behind the metatarsal bones or calluses. On the count of one, the toes are forcibly curled down, and on the count of two they are allowed to relax slowly. This is continued until a count of 200 has been reached.

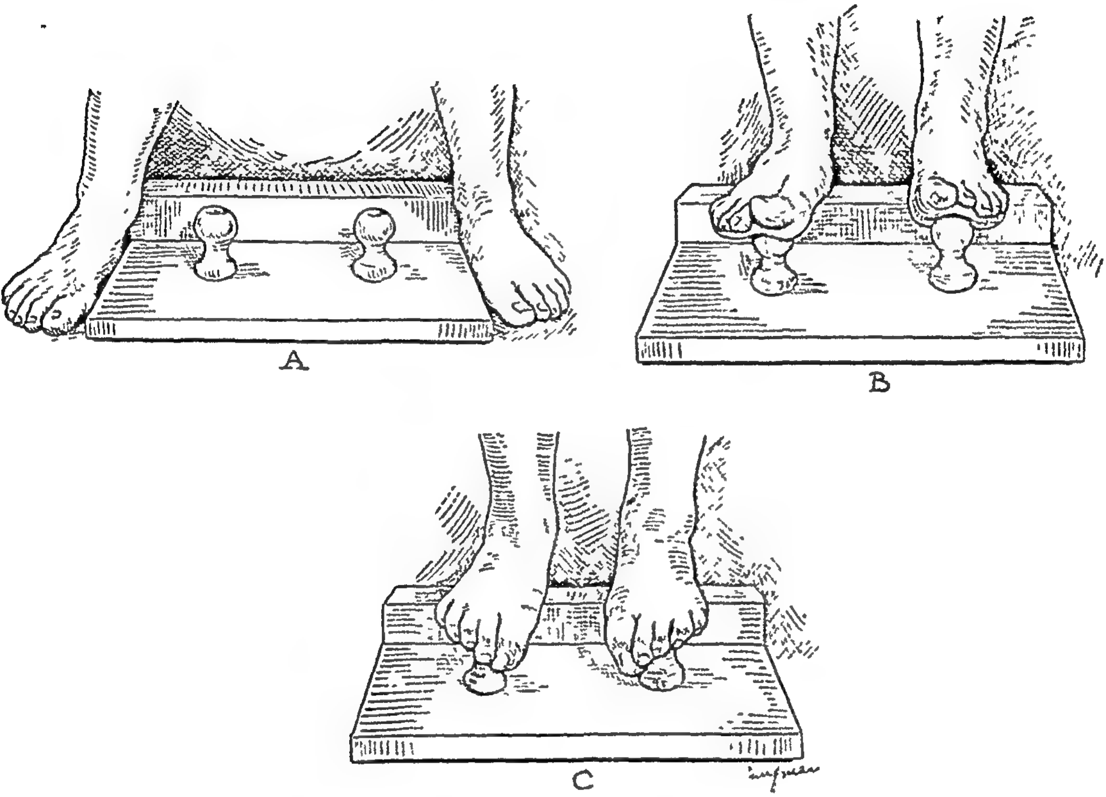


FIG 122.—Door-stop board and exercise for metatarsal arch. No ankle valgus is permissible. (Lewin, courtesy of Am. Jour. Surg.)

2. *Towel Exercise.*—The patient sits in a chair. A large hand towel is spread on the carpet, with the narrow edge facing the patient. Both feet are placed so that the posterior one-half of each foot is on the towel. The towel is grasped first with the toes of one foot and then with the toes of the other. As the toes of the one foot grasp, the patient should relax those of the other. This is carried out until the entire towel is under the feet.

3. *Golf Ball Exercise.*—A golf ball is placed on the rug and rolled under the metatarsal arch for one minute. It is then picked up with the toes of one foot and placed under the toes of the other. The exercise is repeated for another minute. The patient alternates in this manner six times.

4 *Rubber Ball Exercises* —A small rubber ball may be used as substitute for the golf ball

5 *Marble Exercise* —Marbles of various sizes are placed on a rug The patient sits on a chair and picks them up with the toes

6 *Pencil Exercise* —A round pencil is placed on a hard floor and, by means of the toes curled downward, the patient pushes and pulls the pencil around the floor with short, quick movements

Diathermy, inductotherm, negative galvanism, and sinusoidal current are helpful adjuvants in the treatment Occasionally plaster-of-Paris casts are required Less frequently, operation is necessary The various operations for corrections in the metatarsal arch are tenotomy, tenodesis, and tendon transplantations such as the Jones, Hoke, and Sherman operations Hoffmann s operation (Figs 123 and 124), removal of the metatarsal heads, should

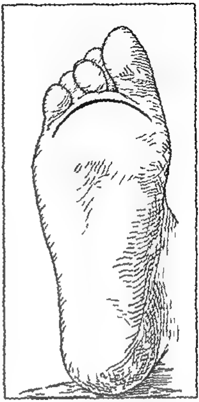
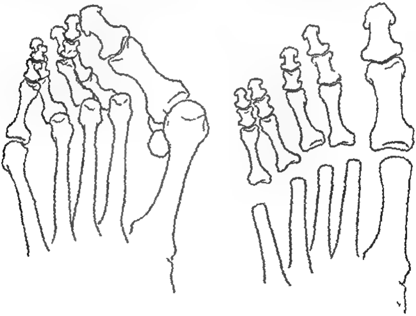


FIG 123 —The line of incision for the Hoffmann operation Resection of the metatarsal heads (The medial portion of the incision is a good approach to the lateral sesamoid)



A B

FIG 124 —Before and after the Hoffmann operation Resection of metatarsal heads

be reserved for extreme cases. Murk Jansen tenotomized the transverse head of the adductor hallucis with excellent results. Spitzy restored the metatarsal arch by a silk suspension ligature passed around the heads of the first and the fourth metatarsal bones. (See Fig. 131 for Krida's operation.) Arthrodesis and arthroplasty of the four outer metatarsal joints is rarely indicated.

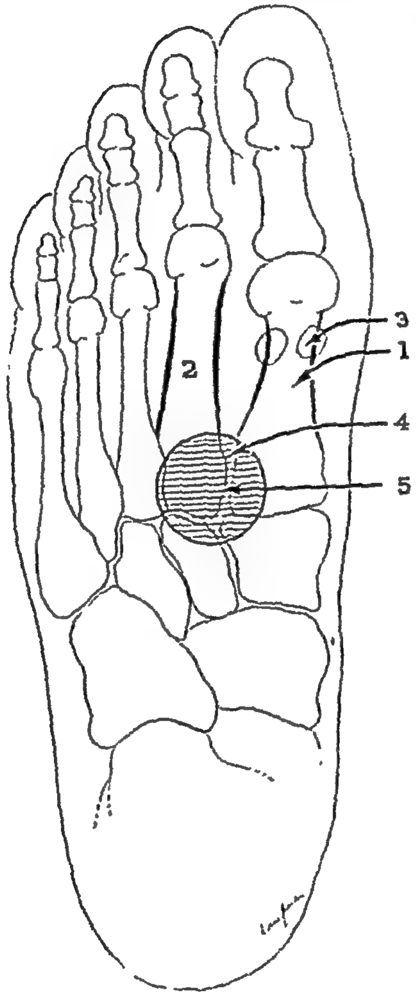


FIG. 125.—The Morton syndrome. Composite representation of components from plantar view. *1*, Short first metatarsal; *2*, hypertrophied second metatarsal; *3*, posteriorly placed sesamoids; *4*, increased space between base of first and second metatarsals; *5*, circle indicates tender spot over basal second metatarsal joint. (Adapted from Morton, Jour. Bone and Joint Surg.; also The Human Foot, Columbia Univ. Press.)

THE MORTON SYNDROME

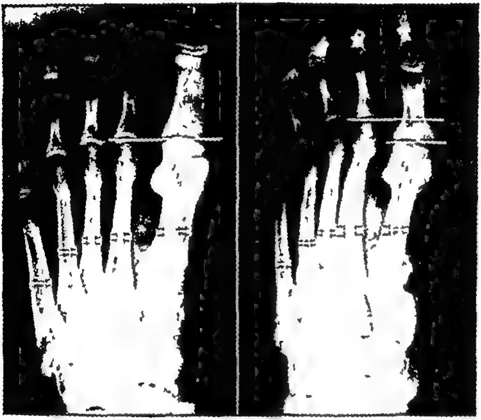
My conception[1] of the Morton syndrome includes the following components: (*a*) causal, (*b*) effectual, (*c*) remedial.

The causal component includes: (*a*) a short first metatarsal, (*b*) a hypermobile first metatarsal segment, and (*c*) posterior displacement of the sesamoids.

[1] Morton personally confirms my interpretation He has given up the term "metatarsus atavicus."

The effect component includes (*a*) hypertrophy of the second metatarsal, (*b*) deep tenderness at the base of the second metatarsal, and (*c*) callosities under the heads of the second and third metatarsals especially the second

The remedial component is made up of (*a*) a metatarsal platform for the head of first metatarsal, and (*b*) a "pronation control" for adults and children, but especially children



A B

FIG 126 --In the ideally designed foot *A*, metatarsal I and II extend forward the same distance and the first is twice as wide as the second Also all four outer metatarsals are the same width The influence of weight bearing upon the development of these bones is indicated (1) in their comparative width and (2) in the strength of their walls—represented in 'square of the wall's thickness (small white squares) In the foot *B*, with a short metatarsal I weight stresses are concentrated on metatarsal II Consequently metatarsal II becomes greatly widened and its walls greatly thickened (Oh Doctor! My Feet! Morton Courtesy of D Appleton Century Company)

Morton considers a short first metatarsal analogous to a short leg of a table He requests that the idea of a normal anterior metatarsal arch be discarded but agrees to the presence of a posterior metatarsal arch His argument is based upon the functional concept that while in action, the second, third, and fourth metatarsal heads come down on the ground, thereby precluding the possibility of an arch while bearing weight

Hypermobility of the First Metatarsal Bone—Morton describes a condition of hypermobility of the first metatarsal bone which is due

to unusually free motion in the joint between the inner cuneiform and scaphoid bones and between the inner and middle cuneiforms. The resulting instability of the inner anterior pillar affects both the metatarsal portion and the longitudinal arch of the foot.

Fig. 127.—Arrows indicate widened space and tender area. (Oh, Doctor! My Feet! Morton, courtesy of D. Appleton-Century Company.)

The most notable structural feature is physiological hypertrophy of the second metatarsal bone. In the "weak foot" of children, hypermobility is a very common factor.

Morton finds that a large percentage of persons present a condition

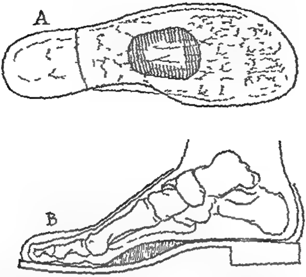


FIG 128 —*A* position of beveled felt pad for metatarsal arch with relation to the metatarsal bones *B* position of pad in shoe (Lewin courtesy of Am Jour Surg)

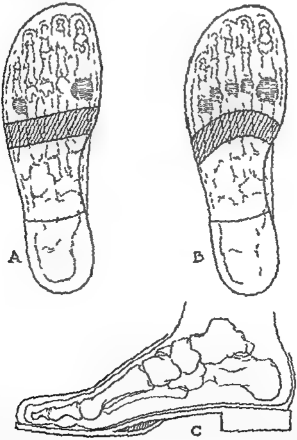


FIG 129 —*A* position of beveled leather metatarsal bar usually $\frac{1}{4}$ inch thick and 1 inch wide *B* position of metatarsal crescent in relation to heads of metatarsal bones *C* side view of shoe and foot with cleat in position (Lewin, courtesy of Am Jour Surg)

of instability of the inner pillar of the foot which is conducive to pain in the metatarsal region and the longitudinal arch. This instability is traceable to the articulation of the inner and middle cuneiform bones.

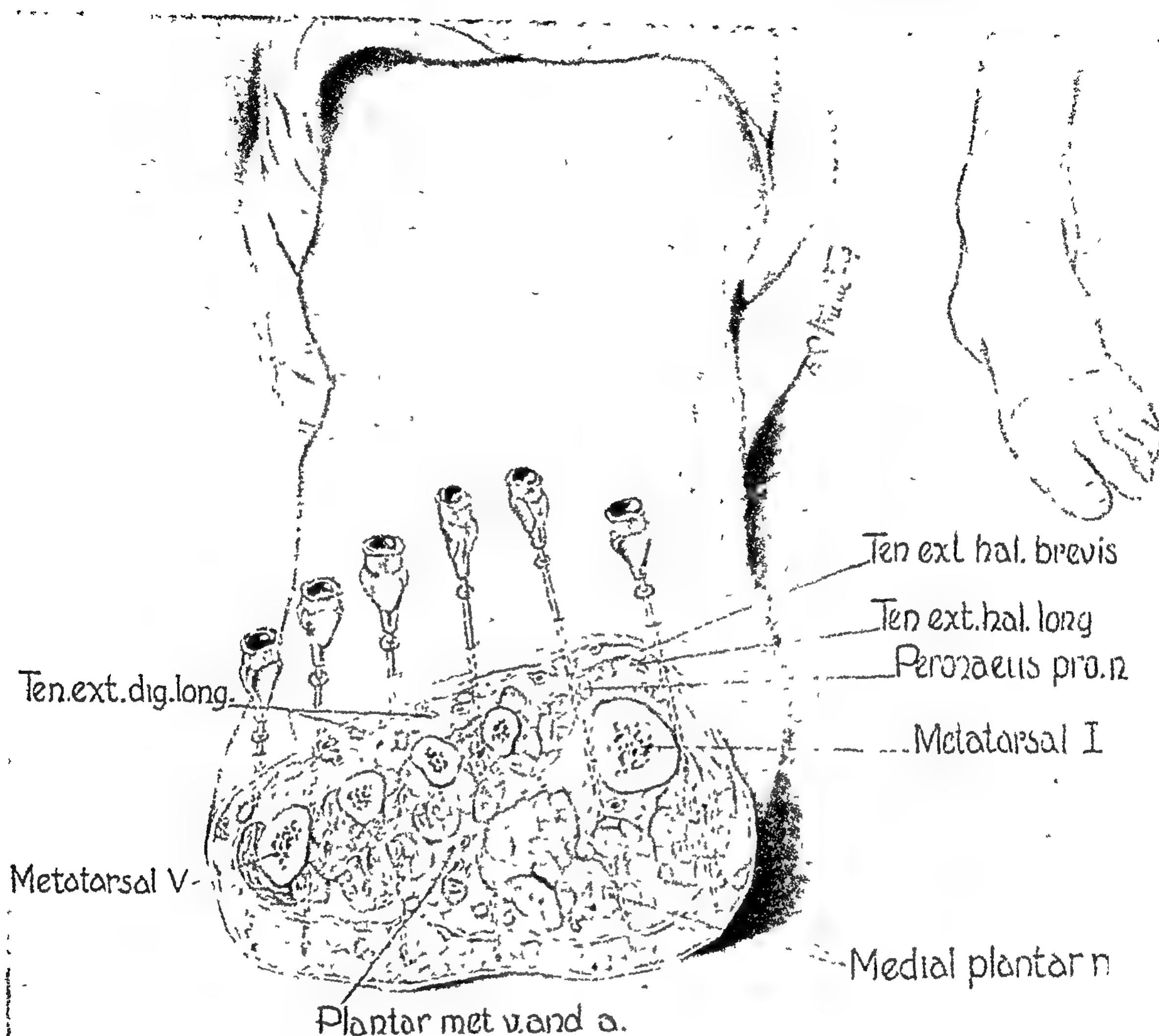


FIG 130 —Cross-section of foot showing method of inserting needles through interosseous spaces. Needles are again withdrawn to skin surface and reintroduced, fan-like. Six to 8 cc. of a 1 per cent novocain solution are introduced into each interosseous space. (Pitkin, courtesy of Am. Jour. Surg.)

Hypermobility of the first metatarsal segment may be inherited or acquired. The most frequent complaint in this condition is pain in the forepart of the foot brought on by walking, dancing, tennis playing, or prolonged standing. One of the earliest and most transient symptoms is a burning sensation in the ball of the foot following activity. This sensation is later replaced by pain of a sharper, more acute character. In some cases there is sudden spasmodic pain located usually about the heads of the third or fourth metatarsal bones and extending

into one or the other of the toes and sometimes up the leg. In the majority of the cases a callosity is found under the head of the second metatarsal bone. The characteristic clinical sign is tenderness on deep palpation of the sole of the foot at about the juncture of the middle

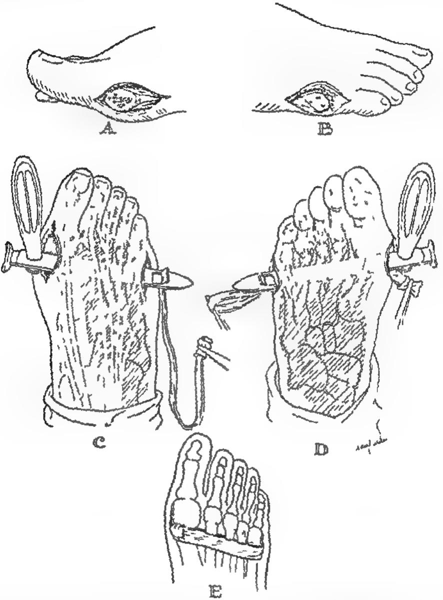


FIG. 131.—Krida's operation for metatarsalgia and splay foot. *A* and *B*, Osteotomy of heads of first and fifth metatarsal bones. *C*, Encircling the metatarsus with a flat fascial band. Curved incisions are made about the first and fifth metatarsal heads. Dorsal view. *D*, The course of the band on the plantar aspect. The method of securing the ends of the band has been modified to include a fascial knot. *E*, Completed operation.

cuneiform bone with the base of the second metatarsal. Short first metatarsals are hereditary and run in family lines. When persons are born with them, Nature starts to reinforce and enlarge the second metatarsals as soon as walking begins. A high-heeled shoe exagger-

ates the harmful effects of a short first metatarsal bone. When the function of the first metatarsal is impaired, the second metatarsal develops added thickness and strength in order to carry the extra load. Added weight on the second metatarsal causes a strain and inflammation of the joints, nerves, ligaments, and muscles deep in the mid-tarsal area. Shortness of the first metatarsal bone is indicated externally when the second toe is longer than the first. Shortness of the first metatarsal bone is present in various degrees in about 50 per cent of feet with metatarsalgic symptoms. The primary fault in both longitudinal and anterior arch foot troubles lies in a functional deficiency of the first metatarsal segment. It results in an overload and an excessive strain upon the second metatarsal segment and its tarsal joints according to Morton.

Dorsal hypermobility of the first metatarsal segment (laxity of its plantar ligaments) is indicated in the roentgenogram (Fig. 127) by an unusual degree of separation between the medial and the middle cuneiform bones.

Two types of hypertrophy may be identified: (1) a widening of the shaft, and (2) a thickening of the cortical wall of that bone.

Some cases of hypermobility are suitable for either the flat-foot operation described by Miller or that described by Morton. In the latter method, an arthrodesis is performed between the inner and middle cuneiform bones and between these two bones and the scaphoid.

The subject of March foot is discussed in Chapter XVII.

CHAPTER VIII

PES CAVUS—CLAW-FOOT

Pes cavus, or hollow foot, is characterized by elevation of the longitudinal arch, depression of the metatarsal arch, and shortening of the extensor tendons of the toes. Hammer toes, corns and callosities usually develop.

The causes are heredity, postural defects, paralysis, trauma, spina bifida, and syphilis. Among the factors responsible are high-heeled shoes which produce postural equinus, excessive use of the calf muscles such as sometimes occurs in ballet dancing, poliomyelitis and spastic paralysis, peripheral neuritis, arthritis, injury, and an habitual posture of the foot such as may be assumed to compensate for a short limb. Fibrositis of the plantar fascia may occur. Hereditary cases appear to be limited to one sex in a family line. Transmission is direct. In the poliomyelitis group the ratio of males to females affected is 6 to 3. The incidence of the condition in males is high at the age of adolescence. Poliomyelitis accounts for more unilateral than bilateral cases.

Pes cavus is apparently dependent upon a neuromuscular lesion. True claw-foot may be due to a lesion of the spinal cord, usually spina bifida occulta or poliomyelitis, with resulting weakness of certain muscles of the foot. It is, therefore, a symptom and not an entity.

Hibbs believed that the cause of this deformity may be either a limit to dorsal flexion or an impairment of the intrinsic muscles of the foot from paralysis, or both. The patients complain of weak ankles which turn easily, an awkward gait, and quick fatigue. They state that they have always had high arches and have always experienced difficulty in being fitted with shoes because of a "high instep." There is injury to the dorsum of the foot which may result in ganglion, bursitis, tendonitis, or bony deformity usually at the junction of the base of the first metatarsal and first cuneiform bones. The deformity is characterized by exaggeration of the longitudinal arch with contracture of the plantar fascia, contracture of the long extensor and flexor tendons, dorsal subluxation of the toes at the metatarsophalangeal joints, and depression of the metatarsal heads (Fig 133). In standing, no parts of the toes come in contact with the floor. There are usually painful corns and callosities under the metatarsal heads. The ligaments and capsules on the dorsal aspects of the metatarsophalangeal joints are contracted. The Achilles tendon may be shortened.

The deformity is one of hammer toe affecting several but usually all of the toes of one or both feet. The toes are strongly dorsiflexed (hyperextended) at their metatarso-phalangeal joints and plantar-flexed at their interphalangeal joints. They are retained in this position

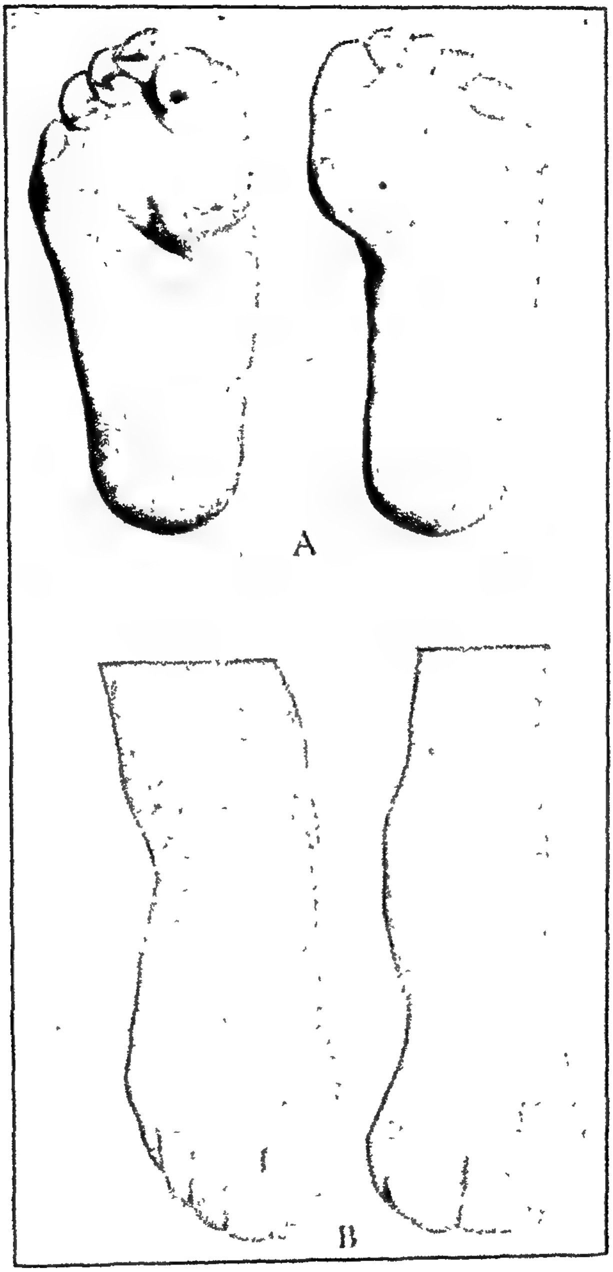


FIG. 132.—Extreme deformities of feet. Pes cavus with ulceration and calluses.

of shortening by adaptation of tendons, ligaments and other soft structures, and by bone changes due to the long-continued new relationship of the articular surfaces. A lower lumbar or upper sacral spina bifida is commonly found.

Equinus is the most common additional deformity It either precedes or is coincident with the cavus

There is limitation of dorsiflexion at the ankle with plantar flexion of the forefoot Corns are commonly found on the dorsa of the toes

Brockway correctly states that the most common aspect of the

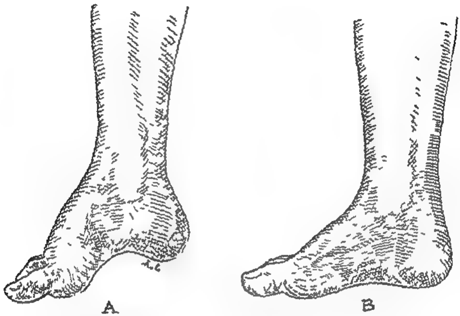


Fig 133 —*A*, Pes cavus hollow foot or talipes arcuatus Note high longitudinal and low transverse arch *B* After Hoke operation (Drawn from photos)

Fig 134 —Roentgenogram of a patient with pes cavus before operation

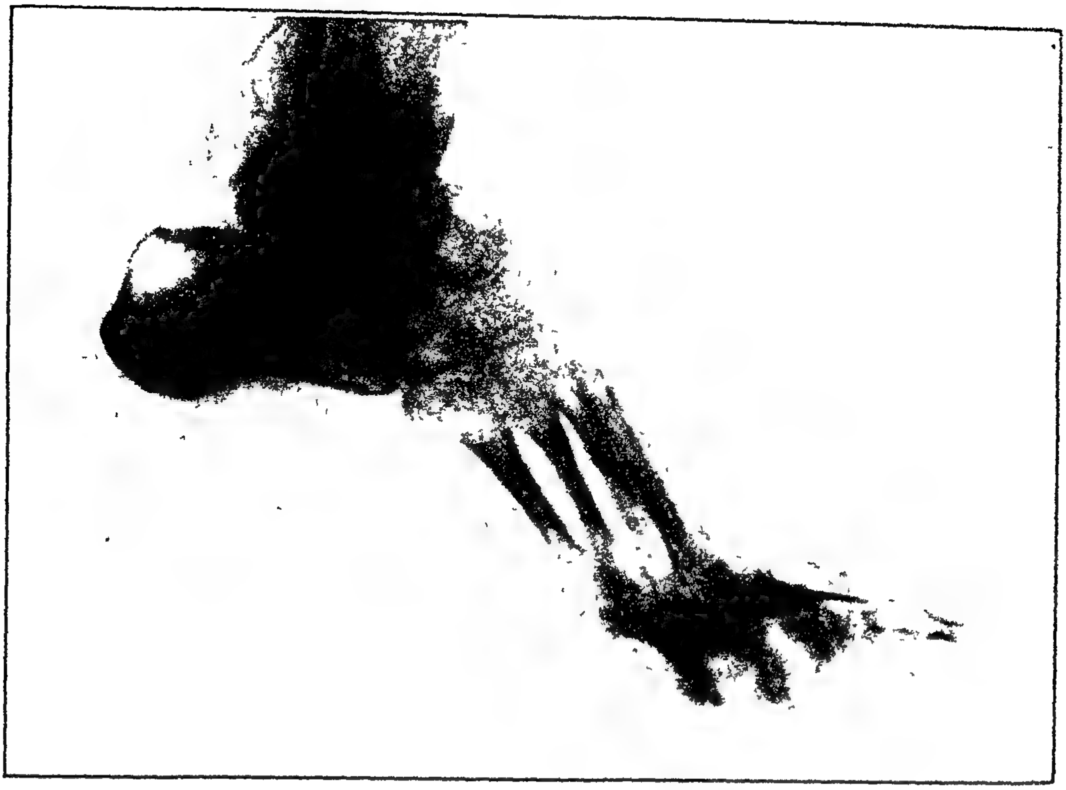


FIG. 135.—Roentgenogram of the same patient after Hoke substragalar arthrodesis.

FIG. 136.—Medial view of the bones of the foot and ankle in a case of talipes equinocavus. Note the increased height of the longitudinal arch, the decrease in height of the metatarsal arch, the direction of the os calcis and the wide separation of several of the bones, especially those adjacent to the astragalus. (Courtesy of Dr. Michael Hoke.)

deformity is a drop of the forefoot The apex of the deformity on the inner border of the foot is more frequently at the navicular-cuneiform joints rather than at the astragalo-navicular joint In either case, the surgical indication is to bring up the forefoot into proper relation with the hindfoot

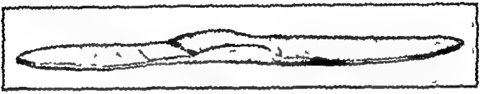


FIG 137 —Insole with anterior arch bar for treatment of claw foot (Cole courtesy of Jour Bone and Joint Surg)

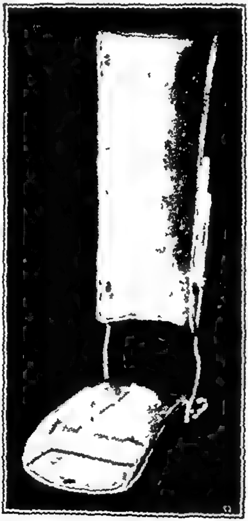


FIG 138—Night splint with anterior arch bar . (Cole courtesy of Jour Bone and Joint Surg)

The next most common element of the deformity is a true equinus in which the heel cord is actually short and is accompanied by the drop of the forefoot In this type it is necessary to lengthen the heel cord in addition to restoring the relationship between the *forefoot* and the hindfoot

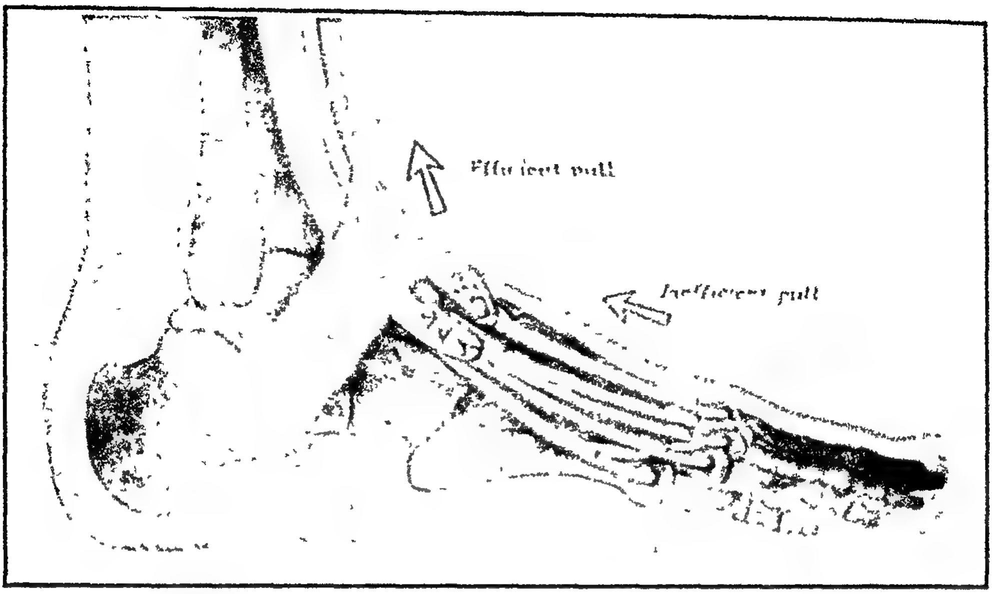


FIG. 139.—Diagram shows how the transplanted extensors of the toes act to the greatest advantage as dorsiflexors of the foot when placed into the cuneiform bones. The loss of power and the inefficiency of the pull, when the tendons lie parallel to the metatarsals after transplantation to the metatarsal heads, are obvious. (Cole, courtesy of Jour. Bone and Joint Surg.)

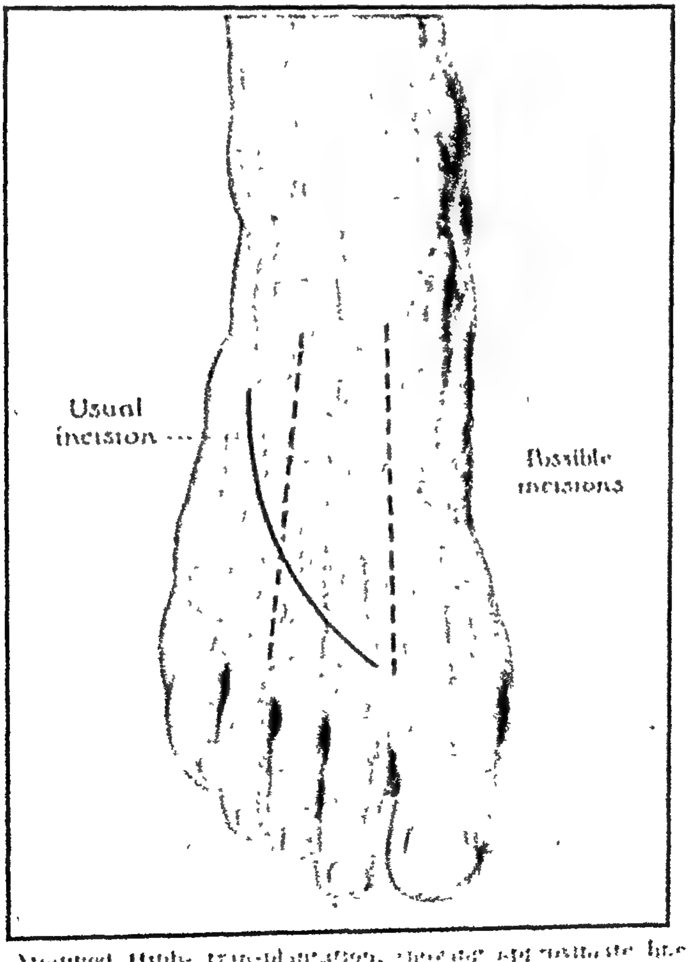


FIG. 140.—Modified Hibbs transplantation, showing approximate line of incision. Two longitudinal incisions can be used if desired. (Cole, courtesy of Jour. Bone and Joint Surg.)

The third element is a combination of drop of the forefoot and a varying degree of calcaneus deformity In this instance the heel cord is too long, and the os calcis forms a greater than normal angle with the longitudinal axis of the tibia The apex of the cavus deformity is more posterior than in those types in which the deformity is only a drop of the forefoot

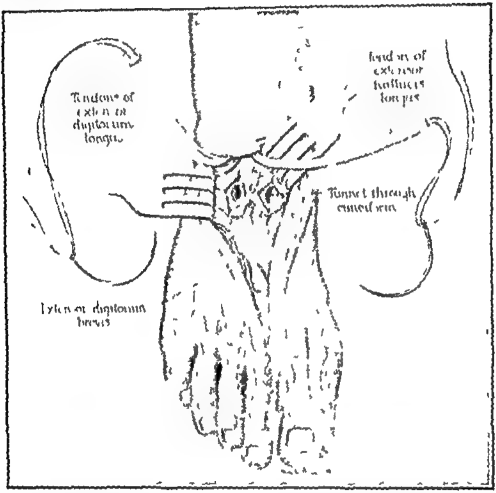


Fig 141 —The tendons shown in Figure 140 have been cut and the four slips of the extensor digitorum longus held together in one bundle by a suture of silk or chromic catgut The tendon of the extensor hallucis longus has a similar suture attached to it The tunnel in the cuneiform bones has been drilled after the periosteum has been scraped away from the crucial incisions (Cole courtesy of Jour Bone and Joint Surg)

In some instances there is an associated varus deformity of the heel In cases of pronounced deformity, there is a high incidence of hammer-toe sufficient to require surgical attention

Treatment —The treatment includes proper shoes, support, exercises, manipulation and operation The treatment during early childhood consists of massage and support During adolescence and adult life, open surgical correction is usually necessary

By persistent treatment some can be checked and others corrected, producing good functional feet

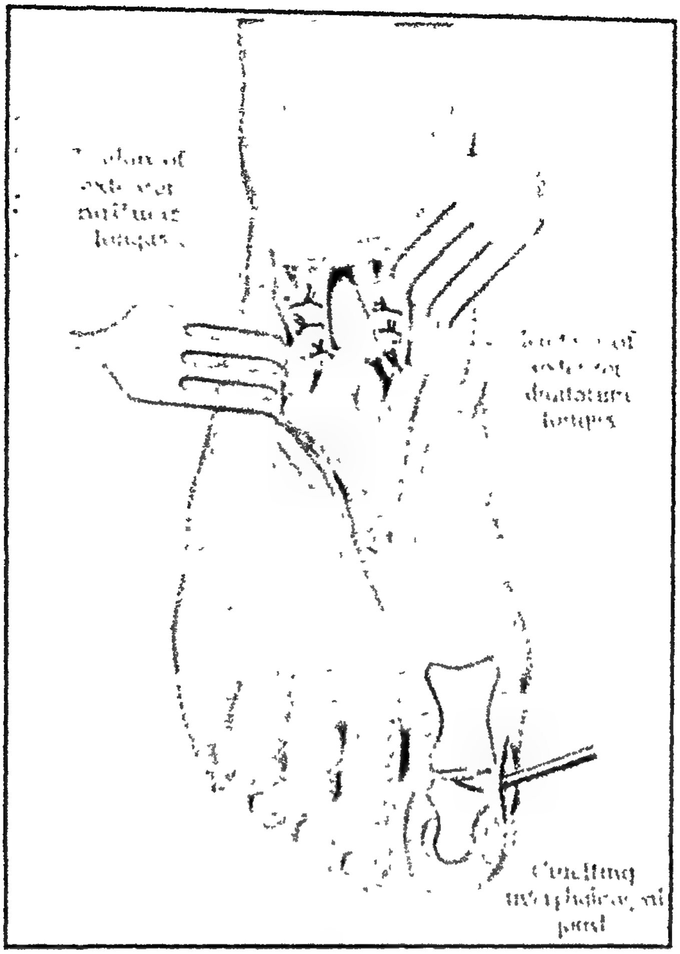


FIG. 142.—The tendons shown in Figure 141 have been passed through the tunnel in the cuneiform bones, the extensor digitorum longus bundle from the lateral to the medial side, and the extensor hallucis longus in the opposite direction. The tendons are held in place by interrupted sutures, the distal one on each side passing through the periosteum. Through a small medial incision the interphalangeal joint of the great toe is curetted in order to initiate ankylosis. (Cole, courtesy of Jour. Bone and Joint Surg.)

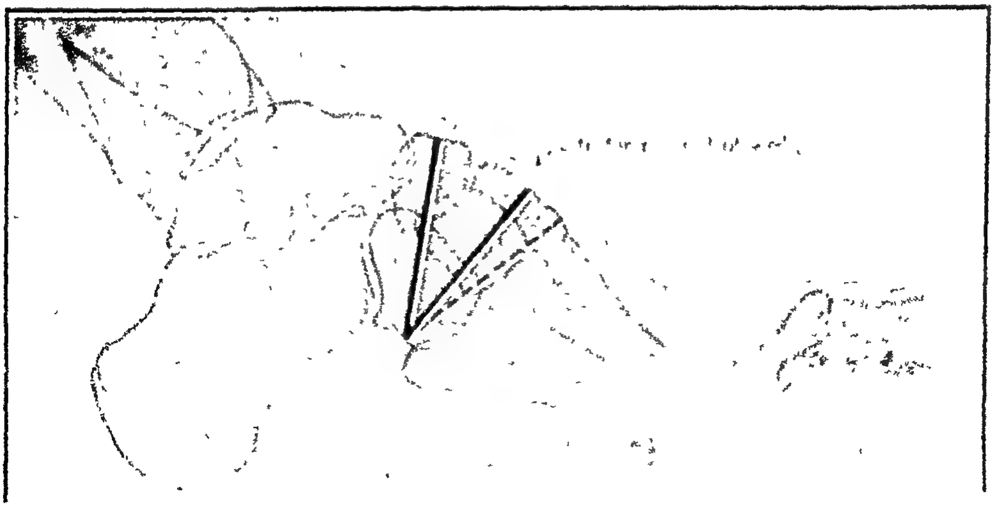


FIG. 143.—A diagrammatic ... of the
in anterior-tarsal-wedge oste... t the
midtarsal joint. (Cole, cour... nd J...

Transplantation of the toe extensors to the cuneiform bones will minimize progressive cavus When wedge osteotomy is necessary to overcome the cavus, an anterior tarsal wedge will restore function and correct the deformity The bone architecture must be corrected

Brockway found that soft-tissue operations are of themselves not adequate except in cases of mild deformity in young patients Likewise, tenotomies and capsulotomies for hammer toes of the severe or the moderately severe variety are disappointing, and the cavus and the concomitant deformities are apt to recur and to progress

His study also indicates that most of the patients with milder deformity are not treated for a sufficient length of time Better results could be obtained by longer immobilization in plaster, followed by proper shoeing, exercises, stretchings, and when necessary, repetition of soft-tissue surgery before severe contractures have occurred

Adaptive ligamentous contractures and bone deformities occur rather early In children of eight or nine years with slight to moderate deformity, these changes are often present to a degree which makes soft-tissue surgery inadequate

Full mobility and lateral motion of the non-paralyzed foot are of fundamental importance Therefore, fusion of the midtarsal joints should be done in only the very severe deformities that cannot be controlled in any other way Younger children seem to tolerate loss of lateral motion for a time, but later, symptoms appear as a direct result of loss of motion Once the foot is rigid, it becomes increasingly difficult to employ conservative treatment for relief of pain and discomfort Brockway concluded that while most of these feet have the external appearance of true equinus deformity, the actual deformity is usually only a drop of the forefoot and requires no lengthening of the heel cord Lengthening of a heel cord which is not short only adds to the original deformity Cavus feet should never be operated upon until roentgenograms with the patient standing have been taken

METATARSAL EQUINUS

"*Metatarsal equinus*" is a term used by Hoke to describe painful deformities of the feet in which there is an equinus or cavus element The anterior ends of the metatarsals are pitched down and found just beneath the skin in the ball of the foot Calluses form beneath them The foot is painful because the anterior ends of the metatarsals dig into the ball of the foot in standing or walking There is also an enlargement of the inferior part of the anterior end of the metatarsal bone This becomes an added source of pain because of pressure

When operation is indicated, Hoke removes the anterior two-thirds of the metatarsal bone by subperiosteal dissection, operates on the bone

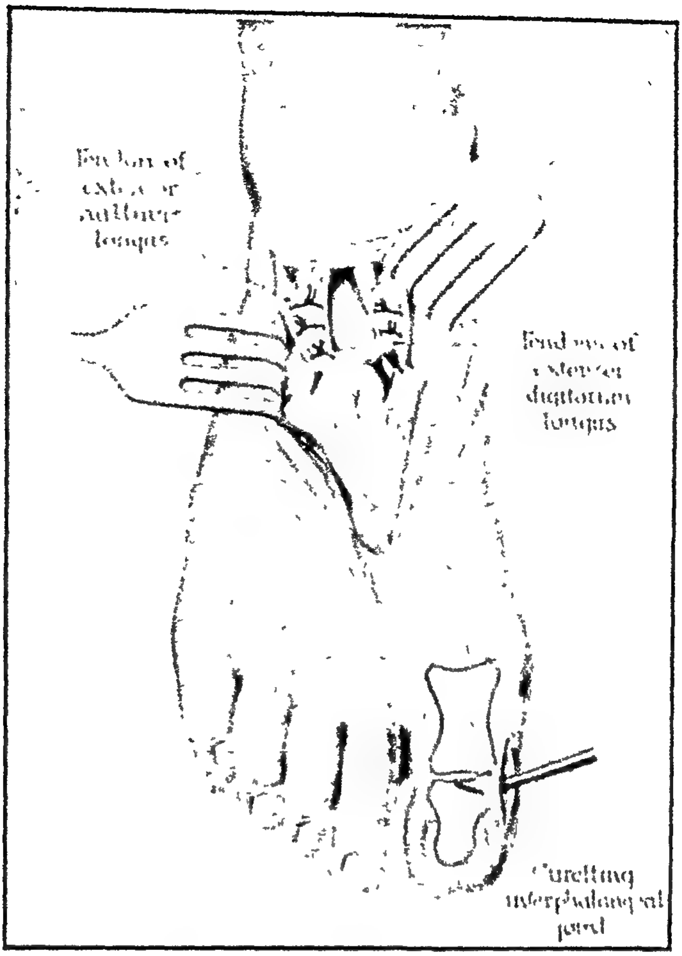


FIG. 142.—The tendons shown in Figure 141 have been passed through the tunnel in the cuneiform bones, the extensor digitorum longus bundle from the lateral to the medial side, and the extensor hallucis longus in the opposite direction. The tendons are held in place by interrupted sutures, the distal one on each side passing through the periosteum. Through a small medial incision the interphalangeal joint of the great toe is curetted in order to initiate ankylosis (Cole, courtesy of Jour. Bone and Joint Surg.)

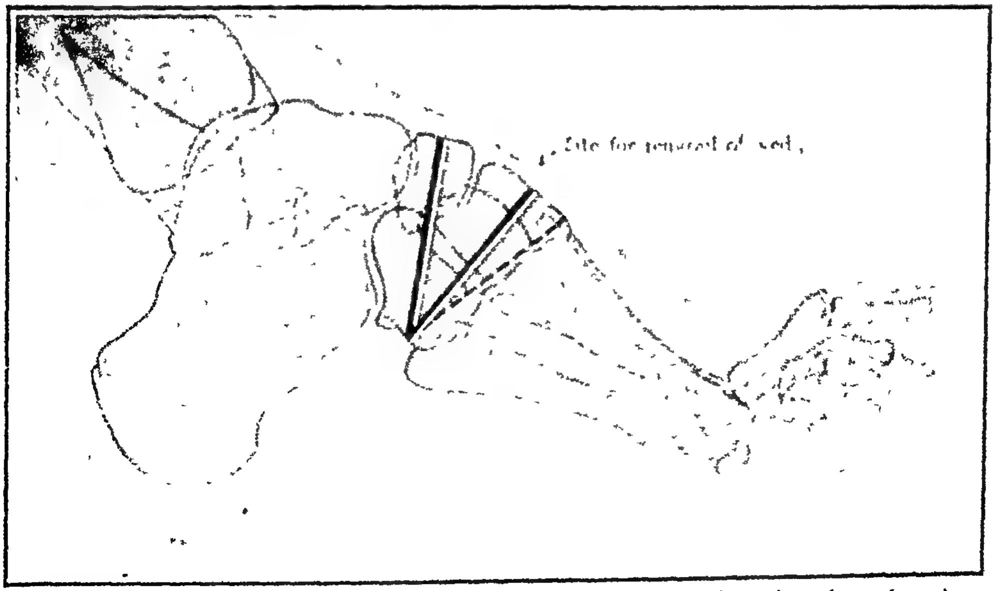


FIG. 143.—A diagrammatic representation of the foot to show location of wedge in anterior-tarsal-wedge osteotomy. Note that the proximal cut is anterior to the midtarsal joint. (Cole, courtesy of Jour. Bone and Joint Surg.)

Transplantation of the toe extensors to the cuneiform bones will minimize progressive cavus. When wedge osteotomy is necessary to overcome the cavus, an anterior tarsal wedge will restore function and correct the deformity. The bone architecture must be corrected.

Brockway found that soft-tissue operations are of themselves not adequate except in cases of mild deformity in young patients. Likewise, tenotomies and capsulotomies for hammer toes of the severe or the moderately severe variety are disappointing, and the cavus and the concomitant deformities are apt to recur and to progress.

His study also indicates that most of the patients with milder deformity are not treated for a sufficient length of time. Better results could be obtained by longer immobilization in plaster, followed by proper shoeing, exercises, stretchings, and when necessary, repetition of soft-tissue surgery before severe contractures have occurred.

Adaptive ligamentous contractures and bone deformities occur rather early. In children of eight or nine years with slight to moderate deformity, these changes are often present to a degree which makes soft-tissue surgery inadequate.

Full mobility and lateral motion of the non-paralyzed foot are of fundamental importance. Therefore, fusion of the midtarsal joints should be done in only the very severe deformities that cannot be controlled in any other way. Younger children seem to tolerate loss of lateral motion for a time, but later, symptoms appear as a direct result of loss of motion. Once the foot is rigid, it becomes increasingly difficult to employ conservative treatment for relief of pain and discomfort. Brockway concluded that while most of these feet have the external appearance of true equinus deformity, the actual deformity is usually only a drop of the forefoot and requires no lengthening of the heel cord. Lengthening of a heel cord which is not short only adds to the original deformity. Cavus feet should never be operated upon until roentgenograms with the patient standing have been taken.

METATARSAL EQUINUS

"*Metatarsal equinus*" is a term used by Hoke to describe painful deformities of the feet in which there is an equinus or cavus element. The anterior ends of the metatarsals are pitched down and found just beneath the skin in the ball of the foot. Calluses form beneath them. The foot is painful because the anterior ends of the metatarsals dig into the ball of the foot in standing or walking. There is also an enlargement of the inferior part of the anterior end of the metatarsal bone. This becomes an added source of pain because of pressure.

When operation is indicated, Hoke removes the anterior two-thirds of the metatarsal bone by subperiosteal dissection, operates on the bone

while it is out of the wound, pitches the toes down, and immediately replaces the bone in its periosteal bed in the normal position, but upside down. From one to three bones may be operated upon at each session. The operation consists of the following steps. The tendons are retracted. A deeper incision is then made down on the metatarsal bone through the periosteum which is dissected from the bone. The bone is osteotomized near its posterior end. The metatarsal bone is then grasped with a sharp pair of forceps, and, by rotating it, the capsule is entirely cut loose at the metatarsophalangeal joint. The metatarsal bone is then removed. After shortening its posterior end so that it will fit accurately, the removed part is replaced and the dislocated toe dropped down into its *normal position. It is reimplanted upside down.* When the bone is turned upside down, the enlarged bottom part of the anterior end becomes the upper part. This is cut off with a bone-cutting instrument. A small tibial graft is used as an intramedullary graft to pin the bone ends together at the site of the osteotomy. The cavity in the sole of the foot beneath the anterior ends of the metatarsals is closed with sutures. The bone is then reimplanted and the periosteum sutured over it.

It is often advisable to arthrodese the first interphalangeal joint of the toe. The operation makes it possible to relieve two painful disturbances of the metatarsal part of the foot—extreme hallux valgus and metatarsal equinus.

A foot plate fitting the arch so that pressure is borne on the heel and the ball, massage, exercises, a metatarsal bar, cleat or crescent on the shoe, and felt or rubber pads inside the shoe are recommended. Galeazzi devised a special type of osteoclast for correcting the deformity.

Various other operations have been recommended. The chief ones were devised by Sherman, Jones, Hoffmann, Steindler, Hibbs, Spitzy, Dickson and Diveley, Galeazzi and Heyman. Unless completely corrected, the condition is prone to recur. In the Sherman operation, the extensor tendons of the toes are anchored into the heads of the metatarsals. The Hoffmann operation is a resection of the metatarsal heads. In very mild cases, tenotomy with forcible wrenching of the foot is sufficient.

Except in cases with a marked bony deformity, the problem can be solved by relieving the contracture of the soft parts and transplanting the long extensor tendons into the metatarsal heads. If the plantar fascia and muscles are taut, they are divided subcutaneously and the foot is manipulated to stretch the plantar structures. The tendon of the extensor longus hallucis is then transplanted into the head of the first metatarsal and an arthrodesis is done at the interphalangeal joint of the big toe. A curved incision is then made on the dorsum of the

foot The extensor longus tendons are divided over the proximal phalanges If the brevis tendons are taut, they are tenotomized After subperiosteal exposure of the distal ends of the metatarsal bones, the capsule of each metatarsophalangeal joint is divided transversely

For mild cases of claw-foot, Dickson and Diveley recommend the following procedure The flexor longus hallucis is exposed by an incision along the inner margin of the head of the first metatarsal bone The extensor proprius hallucis is then isolated and freed from its attachment to the great toe A tunnel is made through the soft parts on the inner side of the first metatarsal posterior to its head, and through it the proximal end of the extensor is passed into the ball of the foot Under tension, the extensor tendon is then attached to the taut flexor tendon with silk or chromicized catgut sutures Finally, an arthrodesis of the interphalangeal joint of the great toe is done A splint is applied to the great toe and a plaster dressing to the entire foot

Steindler's Operation —Steindler's operation is performed as follows On the inner border of the foot a curved incision is made from the back of the heel to a point well in front of the anterior process of the os calcis The entire width of the plantar fascia for a distance corresponding to the length of the incision is exposed Blunt dissection is then done until the space between the short muscles of the foot and the flexor of the big toe is reached A grooved director is then passed between the two The plantar fascia is incised transversely at the line of insertion into the os calcis From this line the fascia and attached short muscles are stripped off subperiosteally from the under surface of the os calcis (Fig 144) The stripping is extended far enough forward to include the inferior calcaneo-cuboid ligament or ligamentum plantare longus By keeping close to the inner tuberosity of the os calcis and proceeding from here outward, one can keep a safe distance from the plantar nerves and vessels The skeletal deformity is then corrected by a cuneiform osteotomy

The head and neck of the astragalus are exposed and a suitable wedge with a dorsal or dorso-lateral base is removed The osteotomy is then extended laterally through the cuboid or the anterior process of the os calcis As a rule these procedures correct the claw-foot deformity completely but in some cases, a tenotomy of the extensor and of the long flexor of the big toe as well as of the common extensors of the toes is necessary

In cavus deformity, due to paralysis of the tibialis anticus muscle, a tendon transplantation should be included after the deformity has been completely corrected The extensor tendon of the big toe may be used to supplant the paralyzed tibialis anticus muscle The method of Hibbs as described by Smith and von Lackum consists of a primary Steindler stripping operation followed after three months by trans-

ference of the extensor digitorum longus and the extensor hallucis longus tendon. The tunnel for these tendons is usually made in one of the cuneiform bones, but may be formed at the base of one or more metatarsals or in the cuboid, depending upon whether it is desired to

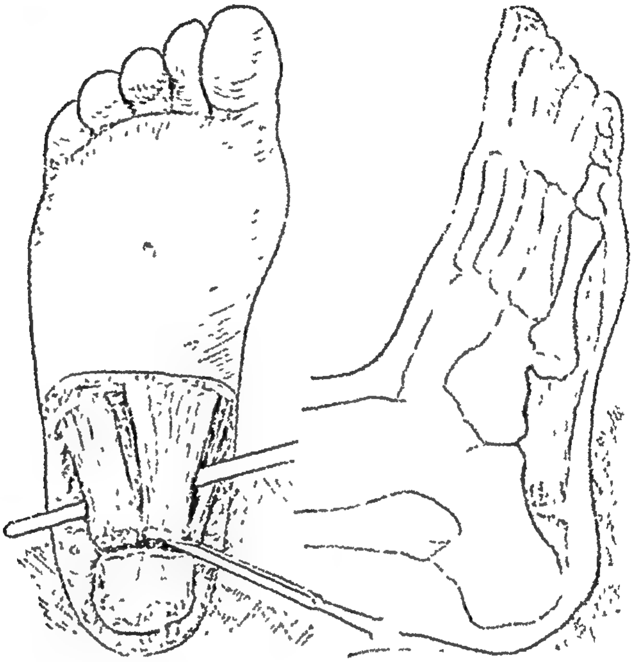


Fig. 144.—Steindler's operation for pes cavus. Stripping of os calcis. (Redrawn from Steindler, courtesy of Surg., Gynec. and Obst.)

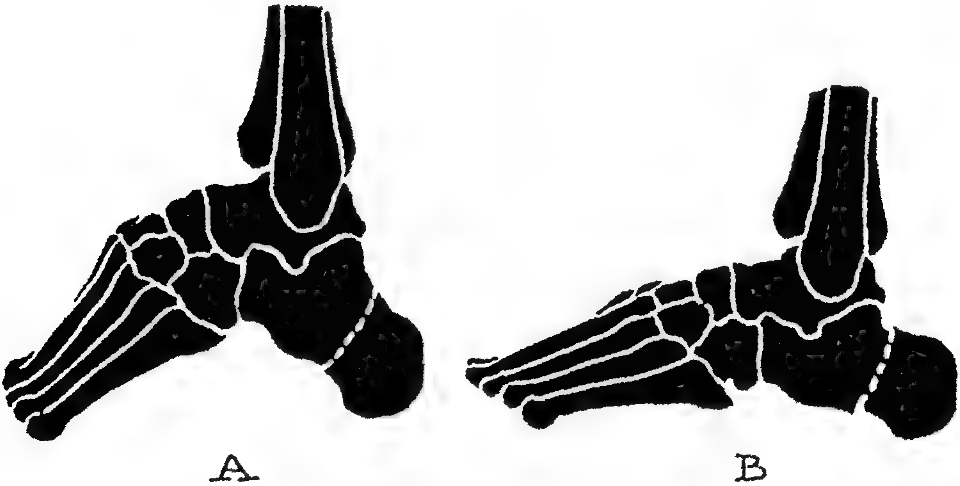


Fig. 145.—Galeazzi operation for pes cavus. Curved osteotomy of os calcis with a shift of posterior portion. *A*, Before operation. *B*, After operation.

transfer the pull of the muscles to the inner, middle, or outer side of the foot. After the periosteum has been incised and reflected, a drill hole is made obliquely downward and pushed from one to the other side of the bone until the two tunnels meet. The angle at the point of

junction is then rounded off with a curette. All tendon sheath is scraped from the surface of the tendons in order that they may become more firmly attached to the bone. The extensor digitorum longus tendons are first drawn through from the outer to the inner side. They are then held with a clamp while the extensor hallucis longus is drawn through from the inner side. The tendons are then sutured to each other with chromic catgut. The foot is placed in plaster with the metatarsals in the corrected position, the toes straight, and a thick felt pad under the sole. The plaster is worn continuously for five weeks and then removed daily for exercises and massage. After seven weeks, the patient is permitted to walk without plaster. Massage and exercises are continued for six weeks longer.

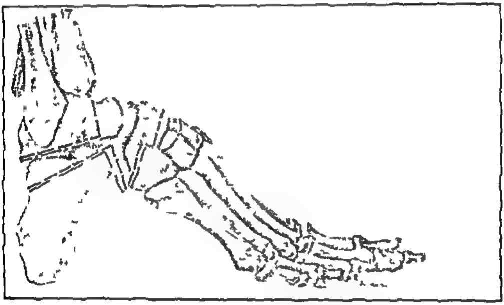


FIG 146.—Diagram showing character of bone incisions in two of the standard methods for stabilizing a foot with calcaneocavus deformity. It is seen that the method of Dunn can be classified as an extensive three joint arthrodesis. — — — Three-joint method. — - — More extensive three joint method (Dunn). (Cole Jour Bone and Joint Surg.)

The Achilles tendon should not be lengthened at this time because its resistance is a great aid in correcting the cavus deformity. It may be lengthened after six months. For cases in which the tibialis anticus muscle has only slight power and there is some shortening of the tendon of Achilles but all other muscles are in good condition, Dunn advises complete overcorrection by means of a wrench, division of the toe extensors, and slight elongation of the tendon of Achilles, if necessary, followed by tendon fusion with the anterior tibial tendon, fixation of the foot in plaster at a right angle and inverted, for two months. When the paralysis is more severe, with laxity of the tarsal joints, he considers arthrodesis of those joints in a normal weight-bearing

position, an essential preliminary to fusion with the anterior tibial tendon.

For calcaneocavus deformity, Dunn advises early fusion of the peroneus longus and flexor longus hallucis to the tendon of Achilles or utilization of a portion of the tendon of Achilles as a ligament to maintain a slightly equinus position of the foot in weight-bearing. For established calcaneocavus deformity he prefers operations on bone to correct deformity and stabilize the foot, and transference of all active posterior tibial and peroneal muscle tendons to an insertion in the tendon of Achilles.

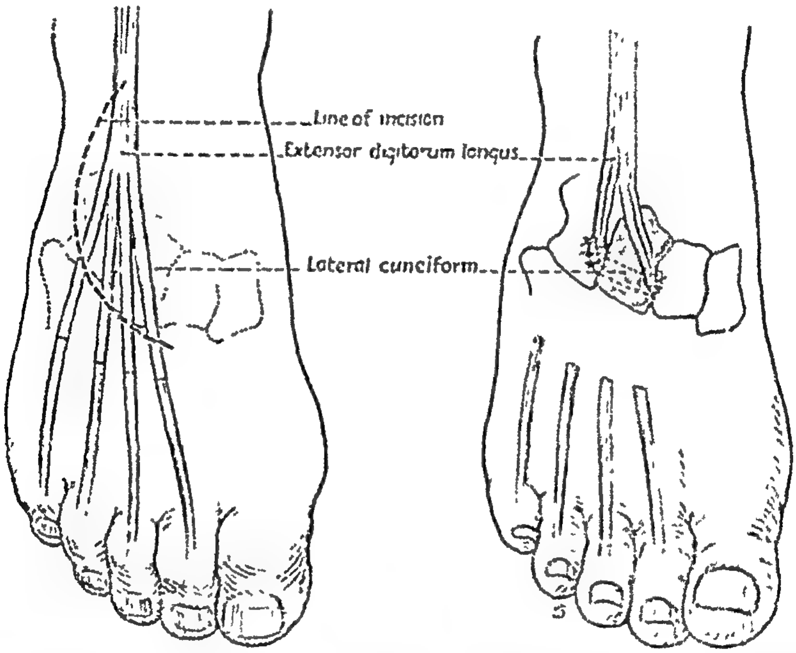


FIG. 147.—Hibbs operation for claw-toes and cavus deformity (claw-foot). Tendons of extensor digitorum longus divided and their proximal ends inserted as a group into lateral cuneiform bone. (Campbell's Operative Orthopedics, courtesy of the C. V. Mosby Company.)

Spitzy's effective operation consists of reflection of the entire heel followed by numerous plantar fasciotomies and capsulotomies. Tenotomies of the toe flexors may be performed. For long-standing and severe cases of rigid and extensive contractures of the toes, Hoffmann advises resection of the metatarsal heads.

Saunders reported on 103 cases treated by anterior tarsal resection, lengthening of the Achilles tendon, and transplantation of the long toe extensor tendons to the cuneiform bones.

Lambrinudi corrects claw-toes by arthrodesis of both the interphalangeal joints of the second, third, and fourth toes and arthrodesis of the interphalangeal joint of the great toe, sometimes driving an ivory peg longitudinally through the phalanges into the metatarsals. Selig, in a recent report, suggested carrying out this procedure using

wire instead of Lambrinudi's ivory pegs If the fifth toe remains hyperextended and in a position in which it is subjected to friction, it is removed

The operation is performed in the following manner First, the extensor tendons of the toes are tenotomized Then, an incision is made over the middle of the extensor tendon of each toe, and the dorsal expansion of the tendon is reflected distally so that the interphalangeal joints are exposed Larger joints are arthrodesed either by a "spike" operation, or by the formation of a wedge in the proximal phalanx which is inserted into a V-shaped cut in the base of the distal phalanx In the smaller terminal joints a simple excision of the articular cartilage suffices

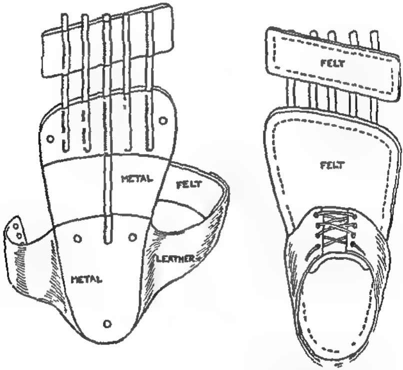


Fig 148 — Lambrinudi's sole plate for fixation of toes after arthrodesis (Burns and Ellis Recent Advances in Orthopædic Surgery courtesy of J and A Churchill Ltd)

Before the dorsal wounds are sutured the toes are fixed in the corrected position to a special sole plate (Fig 148) Fixation is obtained by means of a silkworm gut stitch which is passed from the flexor aspect of the toe immediately round the bone of the proximal phalanx and out through the skin about $\frac{1}{4}$ inch from its insertion The sutures are secured to the corresponding prongs on the sole plate, and the toe piece of the sole plate is slid into position so that the toes remain in a horizontal plane The wounds are then sutured and covered with a dressing

The sole plate and silkworm sutures are left in position for five weeks By the end of that time ankylosis is firm, and exercises for mobilization of the foot and toes are undertaken

position, an essential preliminary to fusion with the anterior tibial tendon.

For calcaneocavus deformity, Dunn advises early fusion of the peroneus longus and flexor longus hallucis to the tendon of Achilles or utilization of a portion of the tendon of Achilles as a ligament to maintain a slightly equinus position of the foot in weight-bearing. For established calcaneocavus deformity he prefers operations on bone to correct deformity and stabilize the foot, and transference of all active posterior tibial and peroneal muscle tendons to an insertion in the tendon of Achilles.

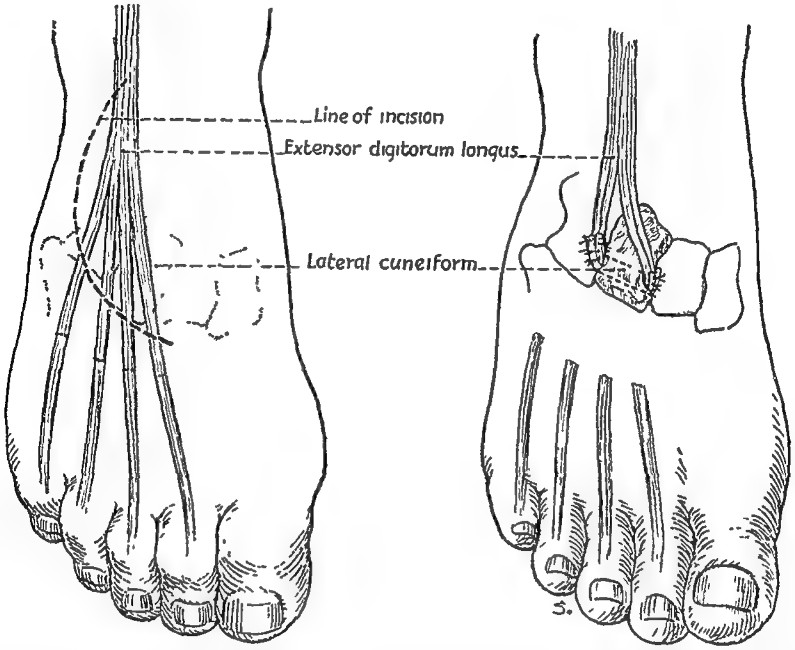


FIG. 147.—Hibbs operation for claw-toes and cavus deformity (claw-foot). Tendons of extensor digitorum longus divided and their proximal ends inserted as a group into lateral cuneiform bone (Campbell's Operative Orthopedics, courtesy of the C. V. Mosby Company)

Spitzy's effective operation consists of reflection of the entire heel followed by numerous plantar fasciotomies and capsulotomies. Tenotomies of the toe flexors may be performed. For long-standing and severe cases of rigid and extensive contractures of the toes, Hoffmann advises resection of the metatarsal heads.

Saunders reported on 103 cases treated by anterior tarsal resection, lengthening of the Achilles tendon, and transplantation of the long toe extensor tendons to the cuneiform bones.

Lambrinudi corrects claw-toes by arthrodesis of both the interphalangeal joints of the second, third, and fourth toes and arthrodesis of the interphalangeal joint of the great toe, sometimes driving an ivory peg longitudinally through the phalanges into the metatarsals. Selig, in a recent report, suggested carrying out this procedure using

wire instead of Lambrinudi's ivory pegs. If the fifth toe remains hyperextended and in a position in which it is subjected to friction, it is removed.

The operation is performed in the following manner. First, the extensor tendons of the toes are tenotomized. Then, an incision is made over the middle of the extensor tendon of each toe, and the dorsal expansion of the tendon is reflected distally so that the interphalangeal joints are exposed. Larger joints are arthrodesed either by a "spike" operation, or by the formation of a wedge in the proximal phalanx which is inserted into a V-shaped cut in the base of the distal phalanx. In the smaller terminal joints a simple excision of the articular cartilage suffices.

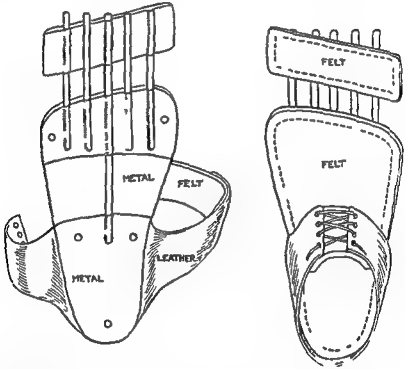


Fig. 148.—Lambrinudi's sole plate for fixation of toes after arthrodesis. (Burns and Ellis: Recent Advances in Orthopædic Surgery; courtesy of J. and A. Churchill Ltd.)

Before the dorsal wounds are sutured the toes are fixed in the corrected position to a special sole plate (Fig. 148.). Fixation is obtained by means of a silkworm gut stitch which is passed from the flexor aspect of the toe immediately round the bone of the proximal phalanx and out through the skin about ¼ inch from its insertion. The sutures are secured to the corresponding prongs on the sole plate, and the toe piece of the sole plate is slid into position so that the toes remain in a horizontal plane. The wounds are then sutured and covered with a dressing.

The sole plate and silkworm sutures are left in position for five weeks. By the end of that time ankylosis is firm, and exercises for mobilization of the foot and toes are undertaken.

CHAPTER IX

AFFECTIONS OF THE GREAT TOE

THE important conditions that occur in the region of the big toe are hallux valgus, bursitis, arthritis, gout, osteomyelitis, sesamoiditis, exostoses and injuries. Bunion is the name applied to bursitis in the region of the big toe joint. Hallux valgus is outward deviation of the big toe with the formation of an overgrowth of bone (exostosis) on the medial side of the big toe joint (Fig. 150). The chief causes of these conditions are heredity, short or pointed shoes, short stockings, infection, and injury. By some, displaced sesamoid bones are believed to be responsible. The most important prophylactic measures are the wearing of proper shoes and proper shoe fitting from infancy on.

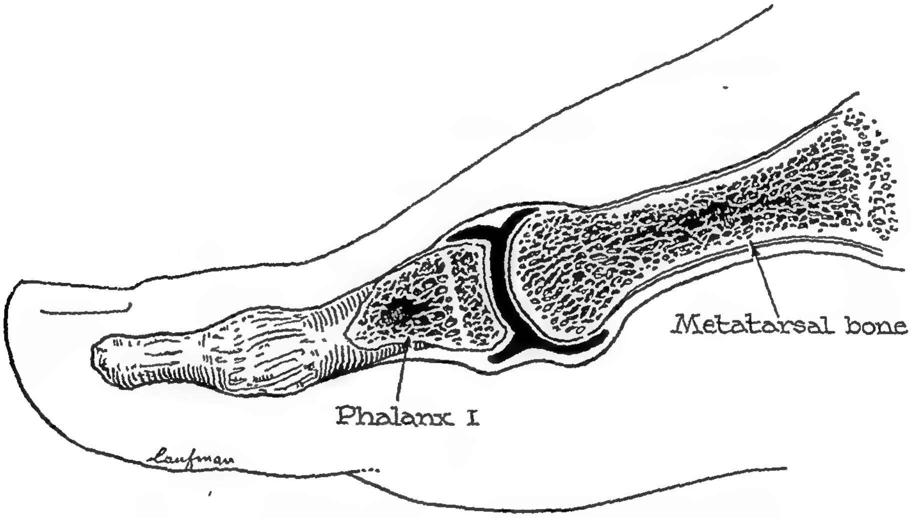


FIG. 149 —Longitudinal section through first metatarso-phalangeal joint.

BUNION

A bunion is a bursa usually found along the medial aspect of the big toe, but occasionally on the dorsal surface. (Fig. 150.) The most important causes of bunion are heredity, short shoes, and pointed shoes The symptoms are pain, which may be intense and present all the time the shoe is worn, and redness and swelling over the involved region. A bunion may be superimposed upon hallux valgus with an exostosis The treatment for bunion may be non-operative or operative. Non-operative treatment requires shoes large and round enough in the toe to prevent pressure on the involved area. For temporary relief a crucial incision of the shoe is excellent. A patch pocket in the shoe may

be effective This may be formed by cutting out a large portion of the shoe and applying a piece of very soft leather A bunion protector or latex shield with edges thicker than the central area may give some relief The operative treatment is aspiration, incision, drainage, or bursectomy

Fig 150 —Severe bunions and hallux valgus treated by Porter operation (Note large plantar callosities in *A*) (Drawn from photographs Porter Surg Gynec and Obst)

HALLUX VALGUS

Hallux valgus, or outward deviation of the great toe, has been ascribed to heredity and to mechanical, ligamentous, muscular, and osseous causes

Truslow proposes the term "metatarsus primus varus" to indicate the situation of the primary focus of that deformity at the proximal end of the first metatarsal bone.

Roentgenograms reveal a distinct angular divergence of the first metatarsal bone from the second; a wedging of either the internal cuneiform bone or the proximal end of the metatarsal or the presence of a wedge-shaped "intermesial bone" (Dwight); and an axis of motion in the tarso-metatarsal joint at an oblique instead of a transverse position to the long axis of the foot. According to Truslow, this is the primary deformity. The roentgenogram reveals also an interosseous triangular

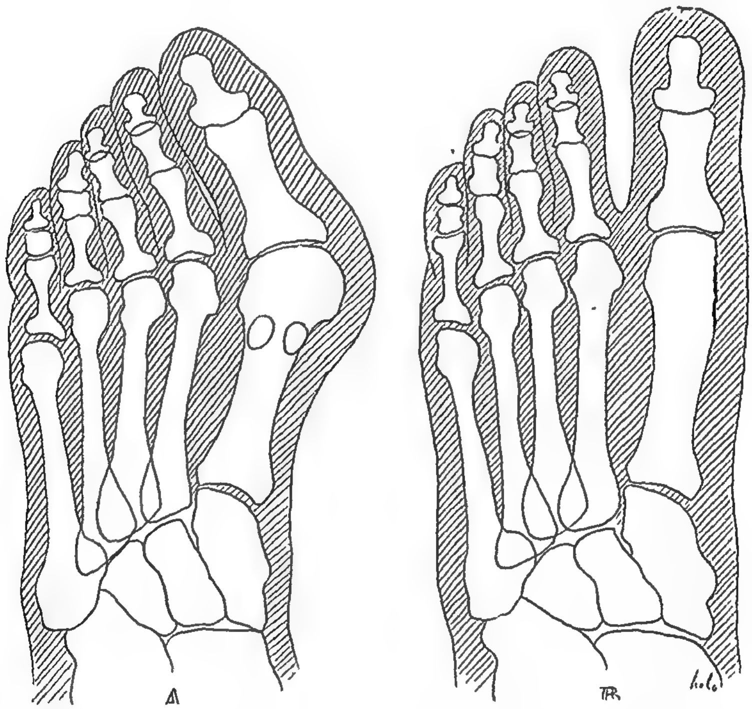


Fig. 151 —Left great toe before (*A*) and after (*B*) operation for hallux valgus. Note result of exostectomy and sesamoidectomy (Redrawn from roentgenograms)

space which is widest between the heads of the first and second metatarsal bones. (Fig. 151 *A*) The outward deviation of the great toe is secondary, as are also any bony enlargements or hypertrophied sesamoid bones.

According to Robinson, the condition is a dislocation of the metatarso-phalangeal articulation of the great toe. It is produced by pressure from within, causing enlarged sesamoids. Heredity is a factor, and almost all cases can be traced to parents or relatives.

Many operations performed for the relief of hallux valgus are unsatisfactory because they fail to correct the deformity completely, leave a stiff joint, or both. Of the numerous operations described, the most noteworthy are those of Hueter, Mayo, Keller, Porter, Silver, Truslow, Peabody, Erlacher, Lapidus, and McBride.

Hueter advised excision of the head of the first metatarsal bone Schede recommended excision of the bursa and removal of part of the head of the first metatarsal not in contact with the phalanx Barker and Reverdin advised removal of the exostoses and a wedge of the metatarsal just above the head

Porter described a satisfactory operation A constrictor may be used A crescent-shaped incision is made just below the edge of the prominence of the head of the metatarsal The capsule of the joint is incised in the same direction and the capsule dissected free from the bone by means of a bunion dissector With a flat chisel and mallet, the first metatarsal, including the entire enlarged inner tuberosity, is removed

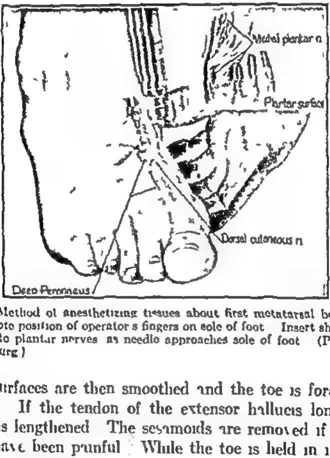


Fig 152 —Method of anesthetizing tissues about first metatarsal bone for bunion operation Note position of operator's fingers on sole of foot Insert shows relation of needle points to plantar nerves as needle approaches sole of foot (Pitkin courtesy of *Am Jour Surg*)

All rough surfaces are then smoothed and the toe is forcibly pulled medialward If the tendon of the extensor hallucis longus is contracted, it is lengthened The sesamoids are removed if the patient says they have been painful While the toe is held in its corrected position, a mattress suture of strong 20-day catgut is inserted and tied The capsule is then closed

The other toes are bandaged so that they approach the big toe When the patient is returned to bed, the feet are elevated on pillows and a cradle is used to keep the sheets away from the toes

The Mayo method (known also by the name of Hueter) is described by Henderson as follows A semilunar incision with the curve upward is made at the metatarsophalangeal joint of the great toe A flap including the bursa is then taken with its base attached to the proximal

phalanx, and extending onto the head of the first metatarsal. The fat having been pushed back from around the head of the bone, a large bone-biter is introduced from without inward to take off most of the articulating surface of the head of the metatarsal bone while leaving sufficient of the enlarged end to serve as a weight-bearing portion. The bone-biter is introduced at an angle of about 75 degrees so that the outer side of the metatarsal bone will be a little longer than the inner side after the piece is removed. The prominence left on the inner side is smoothed down with a rongeur. The flap is then tucked in and the base of the flap sewed to the periosteum of the first metatarsal

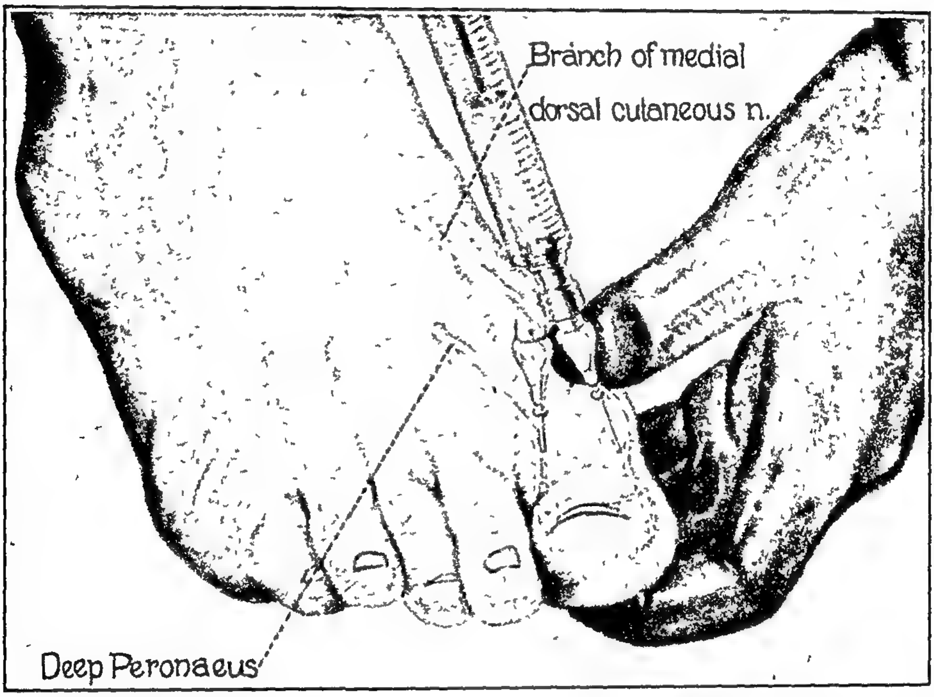


FIG. 153.—For other operative procedures on great toe, anesthesia is produced by depositing 4 to 6 cc. of a 1 per cent novocain solution about its base. (Pitkin, courtesy of Am. Jour. Surg.)

with two mattress sutures of chromic catgut. This serves to straighten the toe and put it in its proper line. To straighten the great toe, a pad of gauze is inserted between the great and second toes.

Silver's operation is begun with the usual curved incision with its base downward. After the fibrous capsule has been exposed by dissection, a Y-shaped incision is made through it, a flap ½ inch long with its base attached to the phalanx being thus formed. This flap is to serve for reconstruction of the internal lateral ligament. Its undersurface is freed of all synovial membrane. The tissues are then dissected upward and downward so as fully to expose the inner condyle. With the great toe retracted outward, a flat chisel is placed against the ante-

rior edge of the inner condyle and the thin cortex of bone, together with the exostosis, is carefully removed, a smooth raw surface of bone being left Care is taken to avoid removing any of the articular surface, only a very little of the cartilage which extends over the side of the condyle is cut away The edge is rounded

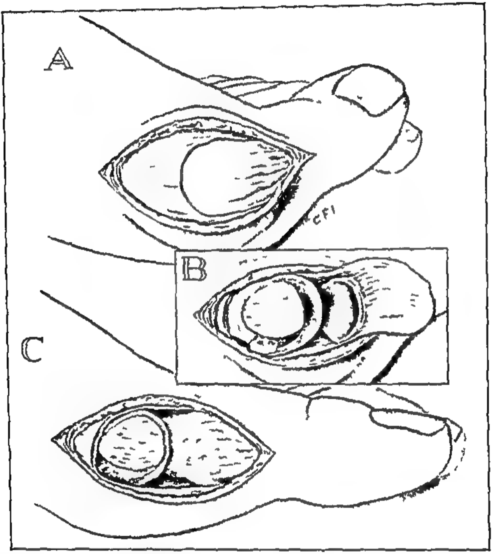


FIG 154 —Mayo bunion operation *A* Line of incision Flap of fascia and bursa *outlined with base attached to proximal phalanx* *B* Redundant portion of bone removed from medial side of head of first metatarsal bone and articular surface *re-modeled* *C* Flap of tissue interposed as a new lining for the joint and fixed by two sutures through lateral capsule Weight bearing surface of metatarsal head is not *disturbed* (Campbell Operative Orthopedics courtesy of The C V Mosby Company)

Traction is then applied to the toe to separate the articular surfaces, a tenotome is inserted, and the external lateral ligament, together with the abductor tendons, divided The latter are attached toward the plantar surface of the phalanx and can easily be reached in this way

The capsule is cut from the top clear down to the sesamoids. If the structures are not divided successfully by this procedure, the tenotome is inserted through the skin on the top of the foot at the outer side of the toe. With the toe held in extreme adduction, the new internal lateral ligament is stitched in place. A chromic stitch run through the upper fibrous flap well back toward the posterior part of the incision is carried forward and then back through the new lateral ligament, and finally passed through the lower flap well back toward its posterior part. When this suture is tied, the new lateral ligament holds the toe firmly in place. As the undersurface of the ligament is in contact with the raw bone, ready adhesion is insured. Next, the upper and lower flaps are drawn together with chromic catgut over the new internal lateral ligament, a procedure which aids in drawing the flexor and extensor tendons, together with the sesamoids, inward. The skin is closed with waxed silk.

Truslow's operation consists of a dorsal incision, cuneiform osteotomy of the redundant bone wedge at the metatarso-cuneiform joint, tenotomy of the shortened long extensor tendon, subperiosteal separation of the contracted parietal capsule of the metatarsophalangeal joint, manual correction of the deformity, and closure of the interosseous space.

Enlarged sesamoid bones and enlargements of the parietal and plantar sides of the metatarsal head can be removed through the original skin incision. Enlargement of the metatarsal head on the mesial side requires a separate incision.

In Robinson's technic for removal of the sesamoids the incision is begun on the undersurface of the head of the metatarsal at a point from $\frac{1}{2}$ to $\frac{3}{4}$ inch back of the protuberance and extended around the prominence to a point a short distance in front of the joint and on the phalanx. The flap is reflected downward, the bursa being left intact. If there are any sharp points or prominences on the inner side of the head, the bursa is reflected forward on the phalanx and the prominences are removed by means of a sharp chisel. After removal of the sesamoids, the bursa is replaced over the denuded bone and sutured to the periosteum. The head of the metatarsal can be easily replaced and the toe will come into position. The outer flap is sutured after the introduction of a small silkworm drain. Fuld transplants the tendon of the abductor hallucis from its usual insertion in the plantar surface of the base of the first phalanx to the periosteum covering the middle of the inner surface of the same bone. Interdigital incision and amputation of the head of the first metatarsal are recommended by Fowler and Davis. Keller removes a portion of the proximal phalanx of the great toe.

Peabody removes the exostosis, drills two holes back of the head of the metatarsal, performs a cuneiform osteotomy, approximates the two surfaces, and ties the two sutures which were passed through the drill holes The cuneiform osteotomy opening with its base medialward, is closed, thereby realigning the metatarsal bone with the toe

Hoke's Operation —The incision extends along the inner border of the foot from the posterior end of the first metatarsal forward over the center of the great toe joint and a little distance along the inner side of the toe Care is taken to avoid cutting through bursa or connective tissue covering the inner side of the great toe joint, because a flap is to be formed from this tissue

A flap is outlined by cutting the connective tissue over the joint along the dotted line The base of this flap is attached to the first phalanx It should not be over $\frac{1}{16}$ inch thick It is carefully dissected with a sharp knife In the next step the periosteum is cut along the shaft of the bone The periosteum is then peeled off the bone Clamps are applied for identification of the juncture of periosteum and capsule The joint is then opened by passing a knife along the joint surface across the top of the joint and around the external side In this way the anterior end of the bone is entirely liberated The periosteal dissection is then completed This entirely frees the bone except possibly from attached sesamoids, which in a few instances are found ankylosed to the undersurface of the anterior end of the bone If the sesamoids are ankylosed, they are pried loose with a blunt instrument With the use of a very thin osteotome and hammer, the metatarsal is then amputated near its posterior end just where the curve in the shaft begins This cutting is done carefully because the bone must not be shattered The bone is grasped with sharp forceps, removed from the wound, and placed in a towel The cut surface of the part of the metatarsal bone remaining in the foot is then inspected, and if it is oblique, it is trimmed off so that the cut surface is transverse to the long axis of the bone

The next step is reconstruction of the anterior end of the first metatarsal It is impossible accurately to carve the anterior end of the bone while holding the bone with the instrument in one hand and the motor saw in the other hand Therefore, in the preparation of the instruments for operation, a vise is attached to a wood block approximately 16 inches long, 12 inches wide, and 2 inches thick This apparatus is sterilized in the autoclave The motor saw is clamped in the vise By this means the operator may hold the bone and cut it in the same way that a woodworker cuts a piece of wood on a lathe The anterior end of the first metatarsal is reshaped so that it is approximately normal in contour and size

A small bone graft is taken from the crest of the tibia measuring approximately $\frac{1}{4}$ inch in diameter, which is to be used as an intramedullary peg for fixing the bone at its posterior end when it is reimplanted. The bone so operated upon is reimplanted in its periosteal bed so that it is approximately parallel with the second metatarsal and the articulation of the toe with it so that there is no longer any outward deviation of the great toe.

In the sewing up of the periosteum after reimplantation of the bone the periosteum is sutured, the suturing being begun at the distal point. The flap is relaid over the inner side of the great toe joint and sutured with tension on the tip of the flap so that it will aid in holding the great toe deviated inward and will have a corrective effect.

The setting in plaster is accomplished by moulding a thin plaster splint around the toe. This splint gives a particular compartment for the great toe and extends to the dorsum of the foot. While the plaster is hardening, the toe is set so that it deviates somewhat inward instead of outward, and in about 30 degrees plantar flexion. The plaster splint may be changed at the expiration of two weeks for removal of the stitches. A new cast is then carefully applied to remain on approximately two weeks longer. At the end of that time it is removed and massage is begun with exercise of the toes for restoration of motion. The patient remains off his feet for two weeks longer, felt pads being placed between the first and second toes. Physical therapy is continued until the function of the toes is regained and the feet are approximately comfortable when stood upon. Wide shoes with toe-posts are worn for approximately three or four months. At the expiration of this time any good walking shoe that is not sharp-toed may be worn.

Lapidus stresses the importance of the metatarsus varus primus as one of the most frequent and most prominent factors of the hallux valgus deformity. He recommends active resection of the first cuneiformo-metatarsal joint. The first metatarsal head can be abducted laterally. Lapidus removes the lateral part of the base of the first metatarsal bone which impinges against the second. He resects the first cuneiformo-metatarsal joint only over its lateral parts, and roughens the adjacent portion of the second metatarsal base with a curet. He removes the bony proliferation over the first metatarsal head.

McBride Operation (Figs. 155 and 156).—The essentials of the operation as stated by McBride are as follows: The conjoined tendon of the adductor hallucis, together with the lateral head of the flexor brevis is released from its attachment to the base of the proximal phalanx and then transplanted into the lateral side of the first metatarsal head with the use of sutures that will draw the first and second

metatarsals tightly together Additional relaxation is obtained by removing the lateral sesamoid, which is usually demonstrated by the roentgenogram, to be displaced and to act as a wedge forcing the first

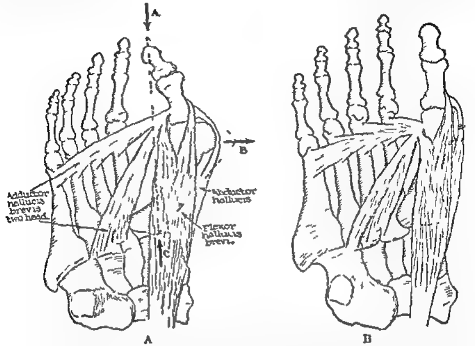


Fig 155 —*A*, Insertions of the adductor the abductor and the flexor brevis muscles in the base of the proximal phalanx Arrows *A* *B* and *C* indicate the direction of forces that create the valgus deformity In the valgus position the adductors and lateral head of the flexor hallucis brevis produce a rotating force *B* Shows relations at end of operation (Redrawn from McBride Jour Am Med Assn)

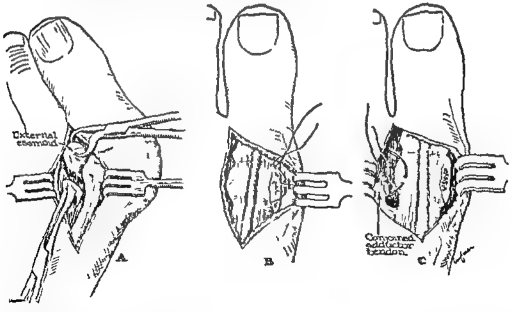


Fig 156 —*A* Technic of removal of the external sesamoid *B* The hypertrophied portion of the metatarsal head has been excised and the bursa shortened sufficiently to maintain the toe in normal alignment *C* Transplanting the conjoined adductor tendon to the metatarsal head (Redrawn from McBride courtesy of Jour Am Med Assn)

metatarsal head medialward. Both sesamoids are removed if they are painful.

The incision is started near the web on the lateral side of the first toe and extended upward and obliquely medialward along the extensor hallucis longus tendon. After the work is completed on the lateral side of the toe, the skin and fascia are dissected and retracted from the medial rotundity of the metatarsal head and joint so as to expose the

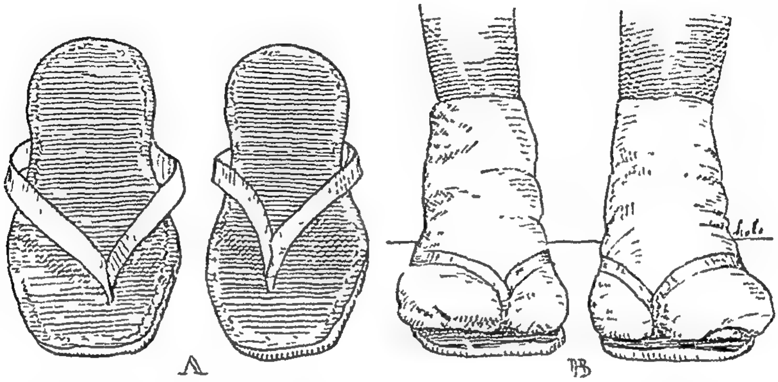


FIG. 157 —Japanese type of stocking and sandals With this slipper, the patient is enabled to walk as soon as the wounds are healed Elastic straps hold the great toes in the position of correction during walking. During walking the patient may perform active exercises, especially adduction and abduction of the toes *A*, The sandals have soles of felt and leather, with corrective elastic straps which separate the great toe from the second toe Heels may be used if necessary. *B*, The patient is wearing the special stockings and sandals, two weeks after bunionectomy operation (Redrawn from Miltner, courtesy of Jour. Bone and Joint Surg.)

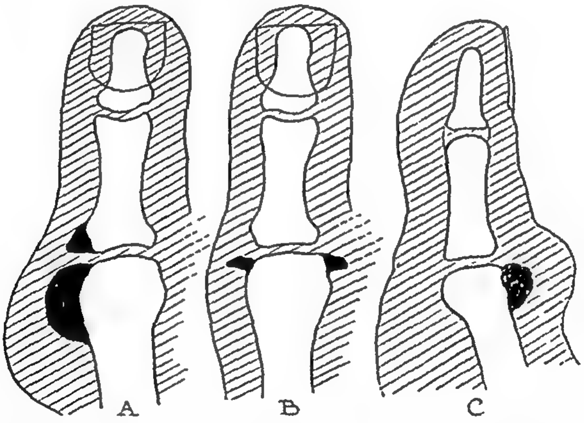


FIG. 158 —*A*, Exostosis of head of first metatarsal bone and proximal phalanx *B*, Medial and lateral exostoses *C*, Dorsal exostosis.

bursa. The bursal fascia is cut transversely and dissected from the bone, and a section is removed to permit suturing it together later with sufficient tension to maintain the toe in slight abduction.

No more bone is excised from the medial side of the head than is necessary to flatten the surface, flush with the shaft of the metatarsal. Care must be taken to leave no spicules of bone or tags of periosteum.

As few catgut knots as possible should be used, and the wound should be dry before closing. A little time and compression after removal of the tourniquet will stop the oozing. During the closing process the toe is held in a slightly over-corrected position and a plaster spica is applied over the toe and ball of the foot. The patient can bear weight in the plaster support about the seventh day.

After any type of operation a stocking made like a mitten with a separate compartment for the great toe will be found useful. (Fig 157.)

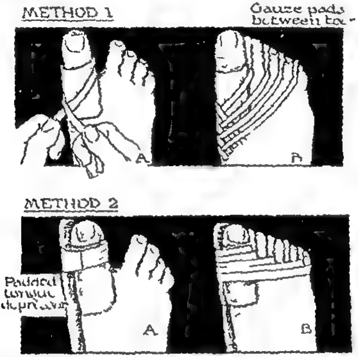


FIG 159.—Methods for applying dressings for bunionectomy. Method 1, consists of half inch strips of adhesive plaster criss-crossed over the inner aspect of the foot pulling each toe into line. This also serves to hold dressing in place. Method 2 employs the use of a padded tongue depressor. Note gauze pads between toes to prevent irritation. (Courtesy of Johnson & Johnson.)

Evaluation of Various Bunion Operations.—The type of operation must be individualized according to the existing situation.

I usually remove both sesamoids through 2 incisions.

I usually lengthen the extensor hallucis longus tendon. A lateral capsulotomy is often a *sine qua non*.

There is a question regarding the reattachment of the conjoined tendon. I have found it often unnecessary. McBride doesn't re-attach the tendon in every case. I rely chiefly on:

1. Removal of the deforming force of the adductor tendon.
2. Removal of the exostosis.
3. Lateral capsulotomy.
4. Imbrication of the medial capsular tissue. (Silver Procedure.)
5. Removal of the sesamoids.

Relation of the Second Toe to Hallux Valgus.—Gottlieb emphasized the importance of correcting the second toe if it is so deformed that it offers an interdigital space for the first toe to fill after the hallux valgus has been surgically overcome. It should be so aligned with the first toe so that it serves it as a splint after the operation.

Operative Correction of the Metatarsus Varus Primus in Hallux Valgus.—Lapidus found in a great majority of cases of hallux valgus, that there is metatarsus varus primus, which is the primary underlying cause of the deformity—hallux valgus occurring secondarily because of shoe pressure. (1) Hallux valgus, or "bunion," is not so much a lateral deviation of the big toe, as the medial protrusion of the first metatarsal head forming bony proliferation because of constant trauma. (2) There

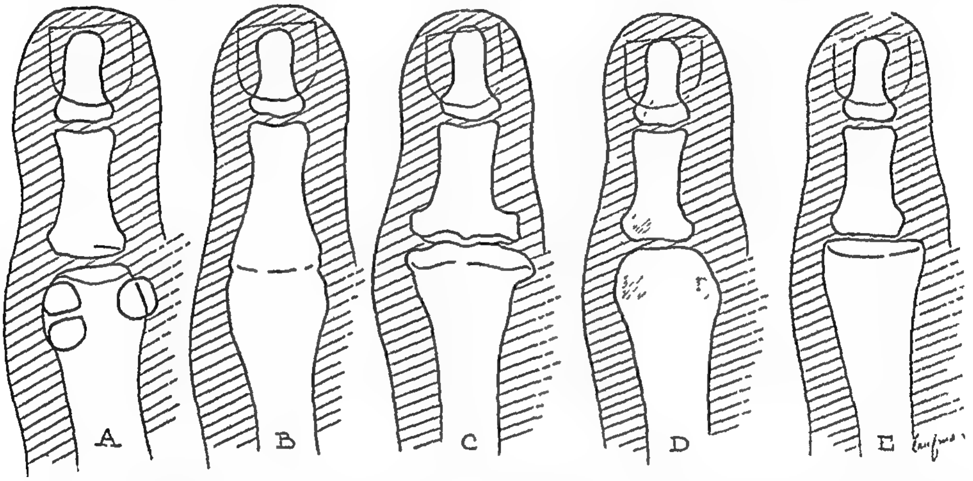


FIG. 160.—Some common conditions occurring in region of big toe joint *A*, Split medial sesamoid. *B*, Fusion of joint *C*, Arthritis *D*, Translucent areas of gout *E*, Flattened metatarsal head

is a type of square foot, with widely spread metatarsal heads and metatarsus varus primus. This foot closely resembles that of primates and is considered atavistic. In a well developed human foot, the first and second metatarsals lie almost parallel, the latter type very seldom developing "bunion;" (3) The atavistic foot has a congenital potential tendency toward hallux valgus formation, and therefore hallux valgus is often hereditary, appearing in youth, mostly in women, because of their types of shoes; (4) No operative procedure is satisfactory unless correction of the metatarsus varus primus is accomplished; (5) Operation for correction of metatarsus varus primus by resection of a small wedge at the lateral part of the first cuneiformo-metatarsal joint is described; (6) Any operation creating shortening of the first metatarsal or the big toe is emphatically condemned as unphysiological, and causing static and dynamic disturbance of the foot; (7) Conservatism and individualization in the indication for operative correction of "bunion" is advocated.

Dorsal Bunion —Dorsal bunion is defined by Lapidus as a pathological condition of the big toe, consisting of a plantar-flexion contracture at the metatarsophalangeal joint with dorsiflexion of the first metatarsal at the cuneiform joint

The hammer-toe deformity of the big toe, or hallux malleus consisting of a dorsiflexion contracture at the metatarsophalangeal joint with a plantar flexion contracture at the interphalangeal joint, is the opposite deformity from dorsal bunion

Dorsal bunions may be divided etiologically into four groups according to the type of associated deformity

1 In cases of hallux rigidus
2 In paralytic deformities of the foot (flaccid and spastic)
3 In congenital club-foot
4 In severe congenital talipes planovalgus

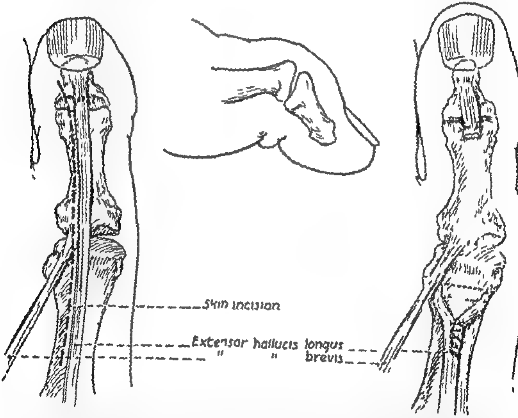


Fig 161 —Modified Jones (Sir Robert) operation for claw toe deformity of great toe Extensor hallucis longus tendon inserted into head of first metatarsal bone arthrodesis of interphalangeal joint distal end of extensor tendon sutured to proximal phalanx to aid in maintaining position of joint surfaces (Campbell Operative Orthopedics courtesy of The C V Mosby Company)

HALLUX VARUS—METATARSUS VARUS

Hallux varus means abduction of the big toe Metatarsus varus, or pigeon-toes, is a remnant of the prehensile function of the great toe A moderate degree is favorable unless it is associated with

Relation of the Second Toe to Hallux Valgus.—Gottlieb emphasized the importance of correcting the second toe if it is so deformed that it offers an interdigital space for the first toe to fill after the hallux valgus has been surgically overcome. It should be so aligned with the first toe so that it serves it as a splint after the operation.

Operative Correction of the Metatarsus Varus Primus in Hallux Valgus.—Lapidus found in a great majority of cases of hallux valgus, that there is metatarsus varus primus, which is the primary underlying cause of the deformity—hallux valgus occurring secondarily because of shoe pressure. (1) Hallux valgus, or "bunion," is not so much a lateral deviation of the big toe, as the medial protrusion of the first metatarsal head forming bony proliferation because of constant trauma. (2) There

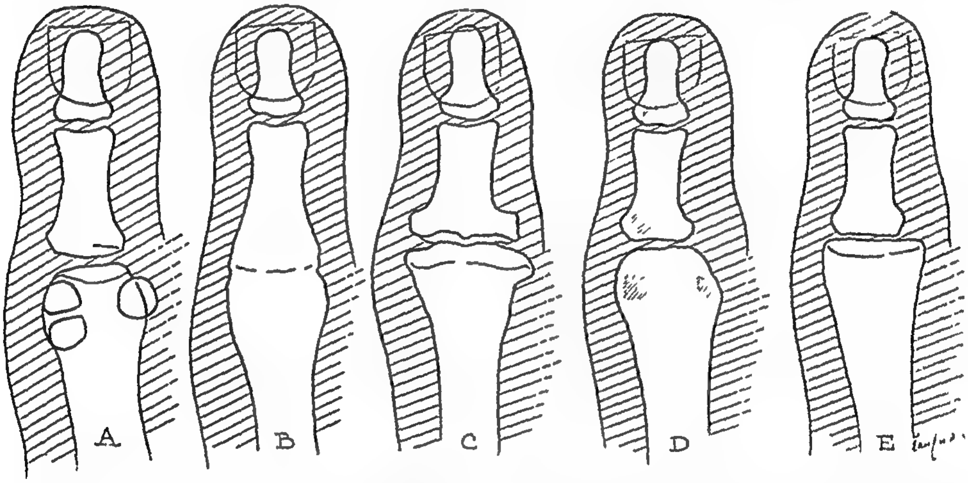


FIG 160.—Some common conditions occurring in region of big toe joint *A*, Split medial sesamoid. *B*, Fusion of joint. *C*, Arthritis *D*, Translucent areas of gout. *E*, Flattened metatarsal head.

is a type of square foot, with widely spread metatarsal heads and metatarsus varus primus. This foot closely resembles that of primates and is considered atavistic. In a well developed human foot, the first and second metatarsals lie almost parallel, the latter type very seldom developing "bunion;" (3) The atavistic foot has a congenital potential tendency toward hallux valgus formation, and therefore hallux valgus is often hereditary, appearing in youth, mostly in women, because of their types of shoes; (4) No operative procedure is satisfactory unless correction of the metatarsus varus primus is accomplished; (5) Operation for correction of metatarsus varus primus by resection of a small wedge at the lateral part of the first cuneiformo-metatarsal joint is described; (6) Any operation creating shortening of the first metatarsal or the big toe is emphatically condemned as unphysiological, and causing static and dynamic disturbance of the foot; (7) Conservatism and individualization in the indication for operative correction of "bunion" is advocated.

1 The Keller-Brandes operation for hallux valgus (or rigidus) in which the proximal two-thirds of the proximal phalanx of the great toe, together with any attending exostosis is removed, affords a simple and safe method for coping with all of the deforming influence producing this deformity

2 The period of postoperative disability is shorter than that of the average exostectomy

3 The ultimate cosmetic and functional results are gratifying both to the patient and the physician

Roller Skating to Correct Pigeon-toes —I prescribe proper shoes with wedges along the outer borders of heels and soles alternately and in combination, felt pads in the shoes to prevent pronation, special "pigeon-toes" shoes, regular orthopædic shoes worn on the wrong feet, *i e*, the left shoe on the right foot and *vice versa*, special exercises on a stencil board to produce valgus, abduction and external rotation of the feet and legs, and the "Charlie Chaplin" walk The Denis-Browne splint is very effective

Roller skating and ice skating often result in a complete cure for pigeon-toes after all other measures fail

HALLUX RIGIDUS

Hallux rigidus is a disabling condition with limitation of movement of the big toe joint

It is impossible to finish a graceful step unless one can flex that joint

Hallux rigidus is usually due to traumatic arthritis of the big toe That area is subject to more trauma than any other part of the body A suit case falls on it, a clumsy man steps on a lady's big toe In the roentgen-ray one sees widening of the joint surfaces The toe may be inflamed The most intractable cases are the rheumatoids An isolated hallux rigidus is correctable by surgery

The toe may be partially or completely rigid or limited in extension or flexion (named "extensus" and "flexus") One does not realize the importance of the ability to dorsiflex the big toe until a rigid toe occurs and prevents completion of the full step The chief causes of hallux rigidus are acute injury, arthritis, and prolonged trauma

Painter attributes most of the trouble to pressure from the shoe during the "breaking in" period at the point where the vamp "breaks" during walking This causes hypertrophy of the bone on the dorsum of the distal end of the first metatarsal (Fig 158, *C*)

Long before these patients have any idea of the beginning of rigidity of their great toe joints they often have the skin rubbed off the top of this joint while "breaking in" new shoes

Arthritis of the big toe joint is usually of the hypertrophic type It produces pain and stiffness at the first metatarsophalangeal joint Roentgenograms reveal overgrowth of bone with exostoses or osteophytes

pronation. The condition is treated by means of a flexible shank shoe with a wedge inserted along the outer border of the sole. The wedge should be from $\frac{1}{8}$ to $\frac{5}{16}$ inch thick. It is advisable to insert a felt pad to protect the longitudinal arch against strain. If a child is directed to walk with his feet in a valgus position–the "Charlie Chaplin" walk–by following the outline of the sole of the shoe stenciled on a board laid on the floor, the foot condition and the inward rotation of the leg will often be corrected. Roller skating is a good exercise. Manipulation of the foot and leg, to produce valgus and outward rotation respectively, is advisable. Marked hallux varus may be corrected by a tendon loop operation around the first phalanx and the second metatarsal. The extensor hallucis longus tendon was utilized in Haas' case, but a free tendon graft from one of the other extensor tendons may also be used for the same purpose. Osteotomies of all the metatarsals are necessary if there is an associated metatarsus varus of the other toes.

An incision 2 to 3 inches in length is made on the dorsum of the foot beginning over the distal third of the first metatarsal bone, and curving laterally around the head of the bone to the distal third of the proximal phalanx. The skin is dissected from the underlying tissues and is retracted so that ample exposure is provided. Instead of using retractors, we have found it most convenient to use retracting sutures which are placed at the lateral and medial skin edges and tied under the plantar aspect of the foot. Before tying these sutures, gauze pads are placed under them at the skin margins. As these sutures are tied, the skin edges are retracted over the gauze pads, and it is no longer necessary to employ an assistant for retraction purposes, and at the same time through the mediation of the gauze pads, the wound is protected from skin contamination. The fascia is now incised longitudinally, and the extensor hallucis tendon is retracted laterally. The prominence of the first metatarsal head is now exposed without removal of the overlying bursa. The capsule of the first metatarsophalangeal articulation is incised transversely, and upon exposure of the articular end of the metatarsal the groove which separates the exostosis from the head of the first metatarsal bone appears. A chisel is now driven into this groove in the direction of the longitudinal axis of the first metatarsal bone, and the entire exostosis is thus removed. Any osteophytes of the first metatarsal head are removed, and the entire head of the bone is carefully smoothed. The proximal two-thirds of the proximal phalanx are now exposed by means of a blunt dissection with a periosteum elevator. It is well to visualize the bone around its entire circumference. The phalanx is now smoothly cut transversely with a bone cutting forceps. It is desirable to remove not less than the proximal two-thirds of the phalanx. The fascia is sutured in place by five or six interrupted chromic sutures.

A word of warning is appropriate in cases of metabolic disturbances such as gout and arthritis that are active Operations do more harm than good unless the underlying condition is corrected

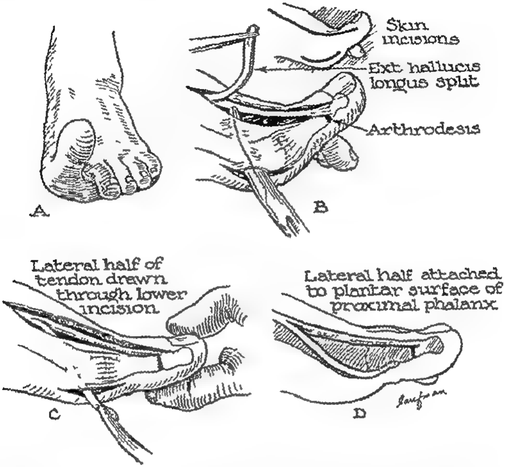


Fig 162 —Operative correction of hallux extensus deformity *A* The deformity *B* Arthrodesis of interphalangeal joint of great toe Extensor hallucis longus tendon split longitudinally from its insertion for distance of 8 or 10 cm Hemostat inserted into lower incision and passed subcutaneously to upper incision *C* Lateral half of tendon delivered through lower incision *D* Correction of deformity

Sesamoiditis involving the big toe joint is discussed in Chapter XIV Hallux extensus sometimes results from poliomyelitis, and should be corrected surgically

On the dorsum of the shoe over the metatarsophalangeal joint there is generally a ridge indicating where this articulation is thickened.

Many cases of incomplete rigidity can easily be relieved by means of a proper shoe, a metatarsal bar, or a piece of steel extending from the heel to the toe, parallel with the big toe, to prevent movement in walking. A proper shoe with pads, transverse arch exercises, massage, contrast sprays, reduction of weight, and a proper diet will relieve the discomfort and improve motion. Sometimes manipulation under anesthesia or manipulation by the physical therapist after the application of heat and massage will do a great deal of good.

Conservative treatment consists of shoes so constructed as to cause no pressure over the metatarsophalangeal joint, together with a plate fashioned after the manner of the ordinary flat-foot support, supplemented by a steel tongue the width of the great toe on its plantar surface and nearly as long as the toe, which projects from the front of the plate. This prevents irritation of the joint cartilage and its consequent proliferation.

In the more abnormal cases, in which there is no dorsiflexion, operation may be necessary. In the surgical treatment the ridge on the dorsum of the metatarsal is chiselled away or a regular Hueter operation is performed. The latter is preferable in cases in which there is an osteo-arthritic diathesis.

Painter recommends a typical Hueter operation as in hallux valgus, and believes that if an osteo-arthritic tendency is present it is wise to refrain from surgery. Mills discusses the subject as follows: Hallux rigidus, when at a stage requiring operation, falls into two classes, *viz:* (1) when the limitation is only in the movement of dorsiflexion; this should be called "hallux non-extensus;" and (2) when the joint is ankylosed either by fibrous periarthritis or by exostosis.

The treatment in the first group of cases is to leave the joint alone and do a cuneiform osteotomy of the neck, with the base of the wedge upward. He closes the wedge-shaped gap by dorsiflexing the great toe as freely as possible and fixes it in plaster for a month.

I believe that tenotomy or capsulotomy on the plantar surface is a useful addition to the operation. In the second type, in which the joint is fixed, or nearly fixed, the operation which gives the best results is complete excision of the metatarsal head. If a bursa is present it should be removed.

I prefer my own type of arthroplasty of the big toe joint, which is shown in Figure 271.

If operation is contraindicated or refused, a clever bootmaker can make the patient comfortable by hollowing out a groove for the front of the great toe and fixing a thin metal plate in the inner side of the sole.

A word of warning is appropriate in cases of metabolic disturbances such as gout and arthritis that are active Operations do more harm than good unless the underlying condition is corrected

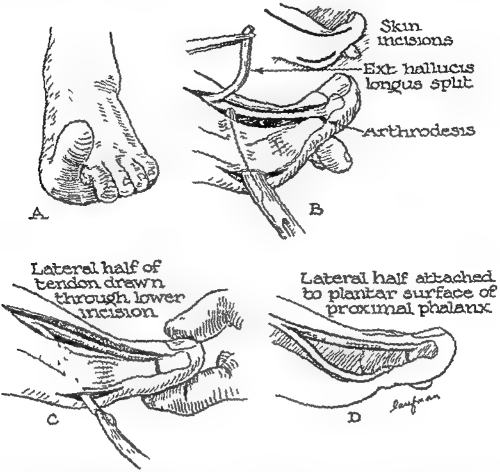


Fig 162 —Operative correction of hallux extensus deformity *A*, The deformity *B* Arthrodesis of interphalangeal joint of great toe Extensor hallucis longus tendon split longitudinally from its insertion for distance of 8 or 10 cm Hemostat inserted into lower incision and passed subcutaneously to upper incision *C* Lateral half of tendon delivered through lower incision *D*, Correction of deformity

Sesamoiditis involving the big toe joint is discussed in Chapter XIV

Hallux extensus sometimes results from poliomyelitis, and should be corrected surgically

CHAPTER X

AFFECTIONS OF THE SECOND, THIRD, FOURTH AND FIFTH TOES

OVERRIDING and underriding toes are common congenital defects. If they are treated immediately by strapping and the treatment is persisted in, practically all can be cured. (Fig. 163.) Those that are not cured by strapping may require operation. Over-long toes (giantism) may require surgery partly because of irritation and partly because an overlong toe prevents proper shoe fitting. Supernumerary

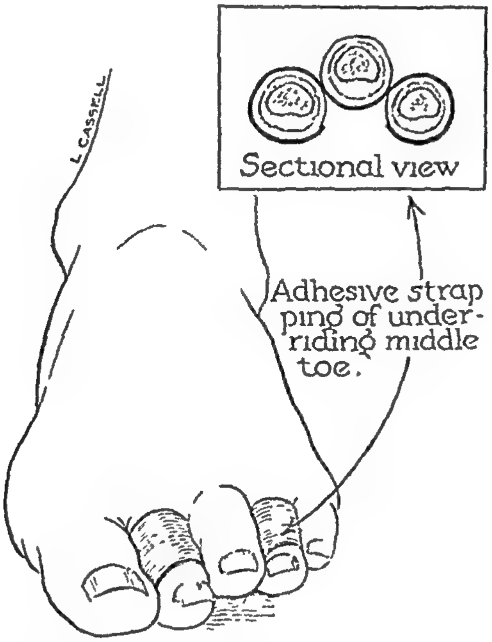


FIG. 163.—Adhesive strapping for underriding third toe

toes should be amputated in early life. Absence of toes is common and usually associated with absence of some of the other long bones of the foot or even of the leg.

Macrodactyly is enlargement of a toe. In some cases the toe is so large that amputation is necessary. Brachydactyly is usually due to a shortened metatarsal bone. It is a rare condition and may be due to a disturbance of the growth of the epiphysis. Syndactylism is the fusion of toes. It may be partial or complete. As a rule it requires no treatment.

AFFECTIONS OF THE FIFTH TOE

The important conditions occurring in the region of the fifth toe include—bursitis or "bunionette," exostosis of the head of the fifth metatarsal, hammer toe, overriding toe, corns, callosities, contracture,

fracture, and dislocation Inflammation of the little toe joint is called "tailor's bunion" (Fig 167)

A bunionette is due to an exostosis on or enlargement of the head of the fifth metatarsal bone A bursa may be superimposed and become inflamed The condition may be extremely annoying and unsightly It prevents proper shoe fitting The causes include heredity, injury, arthritis, and incorrect shoes The treatment is resection of the enlargement similar to that described in the discussion of the treatment of hallux valgus

TRIGGER TOE

Trigger toe is usually due to a stenosing tenosynovitis, a synovioma or sesamoiditis

A ballet dancer complained of inability to bend her right big toe She had been dancing for from two to three hours daily Examination revealed a trigger toe with tenosynovitis of the long flexor tendon Abstaining from dancing for a few weeks, longitudinal and transverse pads in her shoes, exercises, massage, and contrast sprays resulted in improvement Roentgenograms were negative In those cases in which the condition is analogous to DeQuervain's stenosing tenosynovitis, splitting of the tendon sheath is recommended

HAMMER TOES—CLAW TOES

Hammer toes or claw toes are due to heredity, congenital defect injury, arthritis, or improper shoes There is a contracture of the flexor tendon producing a flexion deformity at one or both interphalangeal joints producing a knuckle, on top of which there is often a corn or callus The joint capsule is contracted on its flexor surface

The second toe is very important because it acts as a physiological and mechanical bumper for the great toe During World War I, many young soldiers at Camp Grant and Camp Taylor were sent in to the base hospitals for amputation of "hammer" second toes Such an operation is a great mistake because, when deprived of the buffer support of the second toe, the great toe proceeds to go into valgus deviation, which predisposes to the formation of an exostosis on the medial side of the first metatarsal head, hallux valgus, and bunion Because of the trouble which followed amputation of the second toe, an army order prohibiting removal of the second toe, except under unusual circumstances, was issued

Many operations have been devised for the correction of hammer toes The chief object is to remove the corn if present, resect the opposing bony surfaces, and permit fusion to occur A spike can be made on the end of the proximal phalanx and fitted into a hole in the distal

CHAPTER X

AFFECTIONS OF THE SECOND, THIRD, FOURTH AND FIFTH TOES

Overriding and underriding toes are common congenital defects. If they are treated immediately by strapping and the treatment is persisted in, practically all can be cured. (Fig. 163.) Those that are not cured by strapping may require operation. Over-long toes (giantism) may require surgery partly because of irritation and partly because an overlong toe prevents proper shoe fitting. Supernumerary

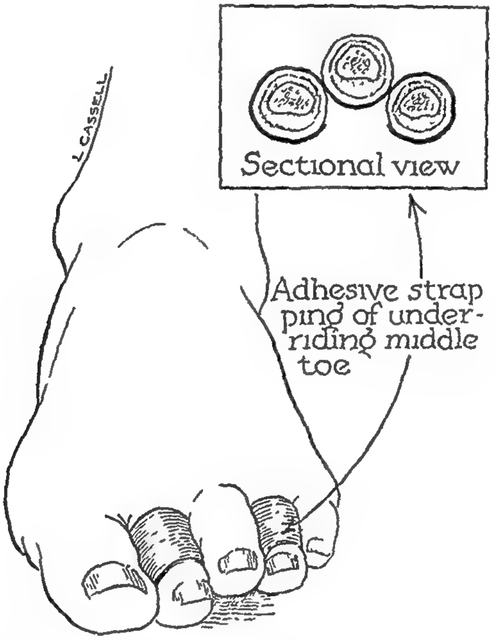


Fig. 163.—Adhesive strapping for underriding third toe.

toes should be amputated in early life. Absence of toes is common and usually associated with absence of some of the other long bones of the foot or even of the leg.

Macrodactyly is enlargement of a toe. In some cases the toe is so large that amputation is necessary. Brachydactyly is usually due to a shortened metatarsal bone. It is a rare condition and may be due to a disturbance of the growth of the epiphysis. Syndactylism is the fusion of toes. It may be partial or complete. As a rule it requires no treatment.

AFFECTIONS OF THE FIFTH TOE

The important conditions occurring in the region of the fifth toe include—bursitis or "bunionette," exostosis of the head of the fifth metatarsal, hammer toe, overriding toe, corns, callosities, contracture,

fracture, and dislocation. Inflammation of the little toe joint is called "tailor's bunion" (Fig. 167.)

A bunionette is due to an exostosis on or enlargement of the head of the fifth metatarsal bone. A bursa may be superimposed and become inflamed. The condition may be extremely annoying and unsightly. It prevents proper shoe fitting. The causes include heredity, injury, arthritis, and incorrect shoes. The treatment is resection of the enlargement similar to that described in the discussion of the treatment of hallux valgus.

TRIGGER TOE

Trigger toe is usually due to a stenosing tenosynovitis, a synovioma, or sesamoiditis.

A ballet dancer complained of inability to bend her right big toe. She had been dancing for from two to three hours daily. Examination revealed a trigger toe with tenosynovitis of the long flexor tendon. Abstaining from dancing for a few weeks, longitudinal and transverse pads in her shoes, exercises, massage, and contrast sprays resulted in improvement. Roentgenograms were negative. In those cases in which the condition is analogous to DeQuervain's stenosing tenosynovitis, splitting of the tendon sheath is recommended.

HAMMER TOES—CLAW TOES

Hammer toes or claw toes are due to heredity, congenital defect, injury, arthritis, or improper shoes. There is a contracture of the flexor tendon producing a flexion deformity at one or both interphalangeal joints producing a knuckle, on top of which there is often a corn or callus. The joint capsule is contracted on its flexor surface.

The second toe is very important because it acts as a physiological and mechanical bumper for the great toe. During World War I, many young soldiers at Camp Grant and Camp Taylor were sent in to the base hospitals for amputation of "hammer" second toes. Such an operation is a great mistake because, when deprived of the buffer support of the second toe, the great toe proceeds to go into valgus deviation, which predisposes to the formation of an exostosis on the medial side of the first metatarsal head, hallux valgus, and bunion. Because of the trouble which followed amputation of the second toe, an army order prohibiting removal of the second toe, except under unusual circumstances, was issued.

Many operations have been devised for the correction of hammer toes. The chief object is to remove the corn if present, resect the opposing bony surfaces, and permit fusion to occur. A spike can be made on the end of the proximal phalanx and fitted into a hole in the distal

phalanx. Complete healing requires four to six weeks. The flexor tendon is divided.

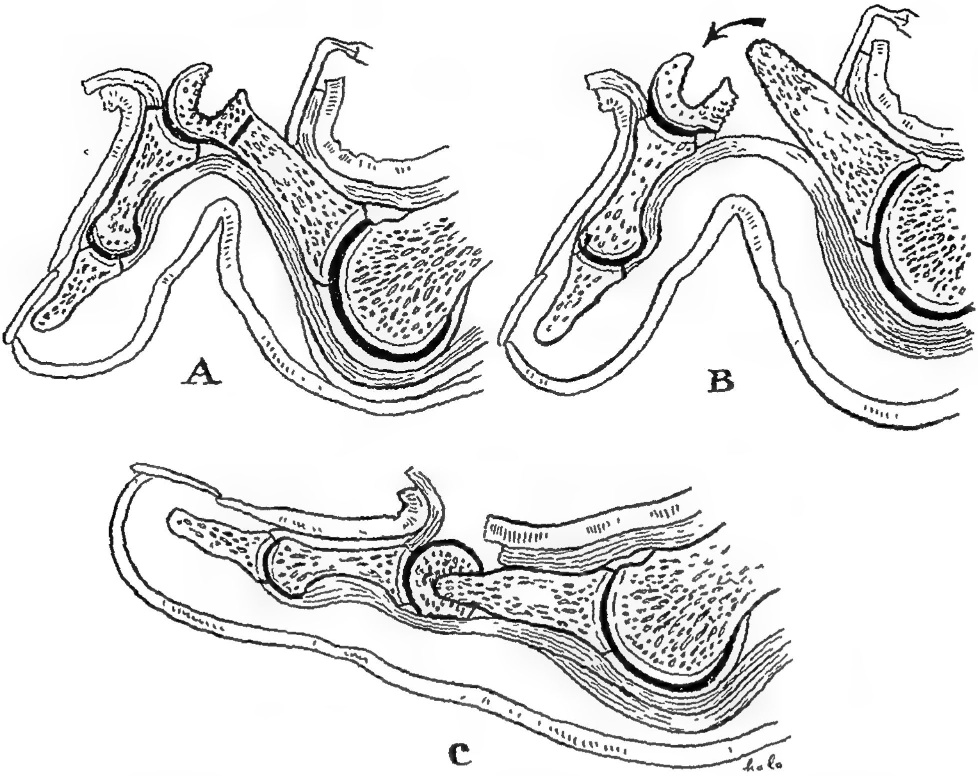


FIG. 164 —Cup and ball operation for the correction of hammer toe (Redrawn from Tierny, La pratique chirurgicale illustrée, abstracted, Jour Bone and Joint Surg.)

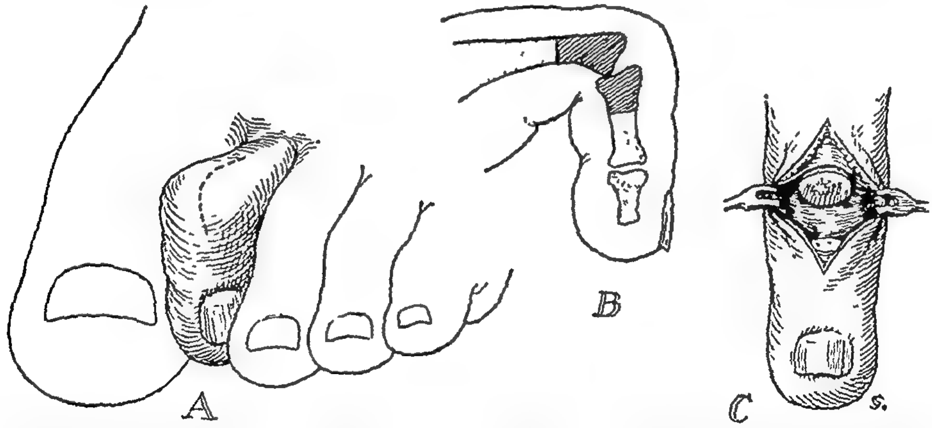


FIG. 165 —*Operation for hammer toe. A, Line of incision. B, Shaded area indicates amount of bone resected from interphalangeal joint. C, Sufficient bone removed to permit approximation of resected surfaces of joint and fusion in straight position.* (Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

According to Young, these deformities are treated most satisfactorily by lengthening the contracted soft structures and performing an arthrodesis of the proximal interphalangeal joint. An arthrodesis is assured by reshaping the head and distal extremity of the proximal phalanx to

resemble a truncated cone and fitting it into a cavity of like shape in the base of the second phalanx

Taylor Operation—After removing adjacent phalangeal surfaces a darning needle or Kirschner wire is inserted lengthwise from the end of the toe through the phalanges holding them in a straight line

Fig 166—Overriding fifth toes

The projecting end of the wire is corked At the end of 20 days the wire is removed

Claw-toe deformity of the fifth toe is not amenable to treatment by an arthrodesing operation, but the deformity and any accompanying

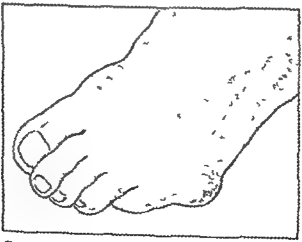


Fig 167— Bunionette or tailor s bunion at head of fifth metatarsal bone

keratoses may be relieved by excising the head and a portion of the shaft of the proximal phalanx

Extensor contracture of the fifth toe may be painful and disabling

By this designation is meant a contracture in which the proximal phalanx is dorsiflexed upon the metatarsal and the proximal interphalangeal joint is plantar flexed. The condition is therefore similar to that occurring in the second toe which is called "hammer toe." It is of variable intensity. The proximal phalanx may be held vertical. The proximal interphalangeal joint is thus subjected to pressure and friction with a resulting callosity which is often extremely painful.

In deformities of the little toe, especially upper displacement which in many cases is a real dislocation with contracture of the extensor tendon, there is a contracture of the flexor tendon and the skin on the plantar surface. The treatment, which varies according to the severity of the condition, includes: (1) proper support of the metatarsal arch; (2) pressure-relieving felt pads on the dorsum of the toe; (3) tenotomy of the extensor tendon; (4) open operation to replace the dislocation, and (5) amputation.

In amputating the little toe it is advisable to resect the fifth metatarsal head, neck, and part of the shaft, in order to avoid a protruding bone in the region of the head which is usually pressed upon by the shoe

Merrill implants the extensor tendons into the metatarsal bones. The resulting muscle pull raises the metatarsal head and often relieves an associated metatarsalgia. He illustrates the mechanics of the combined procedures. It is not often necessary to do an arthrodesis of the middle phalangeal joint because the toe will usually stay in place when the excessive pull of the flexor and extensor tendons has been lessened. The toe is held extended by splints.

Lord excises the head of the fifth metatarsal and, by making an incision on the mesial side downward between the fifth and fourth toes, forms a V of the soft tissues pointing backward on the flexor surface. He then extends this incision backward from the point of the V onto the sole of the foot. The V-shaped tongue is carried as far backward as necessary and secured with sutures to hold the toe down or in a straight position.

In Freiberg's operation, a dorsal incision is made in the axis of the toe from a point $\frac{1}{2}$ inch proximal to the head of the metatarsal to the proximal end of the middle phalanx. The extensor tendon is then cut at the interphalangeal joint and the tendon turned up to the upper end of the incision. The end of the tendon is denuded by scraping with a knife. A kangaroc tendon suture is inserted into the end of the tendon, the ends being left long. The proximal phalanx is then excised *in toto*. The excision is done most easily by beginning at the proximal end. After its accomplishment, a hole is bored through the metatarsal head from the dorsum until the drill can be felt through the sole. By means of a $\frac{3}{16}$-inch reamer this hole is made into a canal. Both ends of the kangaroo suture are threaded into the eye of a straight

needle, which is then thrust through the bone canal and made to emerge in the sole of the foot. One end of the kangaroo suture being withdrawn from the needle, the needle is made to reenter the opening in the skin through which it came, but in such a way that it appears in the dorsal wound, mesial to the head of the metatarsal bone and very close to it. The second end of the kangaroo suture is then threaded into a straight needle and passed back through the same skin opening, but to the lateral side of the metatarsal head. When the ends are tied, the tendon will be held firmly within the bony canal.

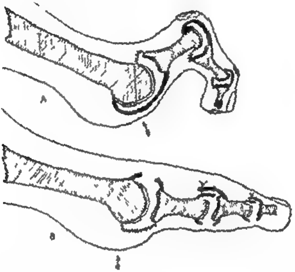


FIG. 108.—Schematic drawings of the hammer toe before (A) and after (B) the operation. The corrugated line represents the part of the joint capsule which has become contracted; the heavy black line, the capsule which has been put on stretch. The articular cartilage is shown by a double line with cross striations. Note that in the hammer-toe weight is borne over the cartilaginous part of the metatarsal head through the overstretched plantar capsule (arrow). Moreover, the weight is borne over the skin on the anterior part of the toe, where the skin is comparatively thin and without the fat padding which is found over the ball of the toe (shown by arrow in B). This is the *reason* that tenderness is often found in this region. Concentric lines represent the corns. Solid black areas in the phalanges show the parts of the bone which sometimes must be shaved off. Note the dorsal subluxation of the basal phalanx in the metatarsophalangeal joint and the plantar subluxation of the middle phalanx at the proximal interphalangeal joint. (Lapidus, courtesy of Jour. Bone and Joint Surg.)

My bone rongeur is very effective in quickly excising the opposing joint surfaces leaving the sides parallel for fusion in a straight line.

Lapidus' Transplantation of the Extensor Tendon for Correction of the Overlapping Fifth Toe.—There are three main components of the deformity:

1. Adduction contracture of the fifth toe toward the fourth,

2. Dorsiflexion contracture of the fifth toe at the metatarsophalangeal joint,

3. External rotation of the fifth toe around its long axis, so that its nail faces laterally.

All these changes take place mainly at the metatarsophalangeal joint of the fifth toe. Adduction may also be present at the proximal interphalangeal joint.

Lapidus' procedure for correction consists in running the distal stump of the extensor longus tendon, with its insertion intact, througl. an oblique spiral channel across the plantar surface of the toe, and implanting it into the conjoined tendon of the abductor and short flexor of the fifth toe, after dorsal and medial capsulotomy of the fifth metatarsophalangeal joint. The operative procedure not only corrects the main three components of the deformity, but also utilizes the muscle power of the abductor and short flexor for active maintenance of the correction. (Remark: There is no doubt the deformity can be corrected, but in many cases the procedure of choice should be amputation.)

Lantzounis devised a periosteo-capsular procedure for the correction of congenital dorsal subluxation or congenital overlap of the fifth toe.

These fifth toes, because of their dorsal malposition, cause symptoms resulting from shoe pressure. Soldiers with this deformity find drilling and hiking quite arduous. Pressure symptoms invariably develop about the plantaro-lateral aspect of the fifth metatarsal head.

CHAPTER XI

DISTURBANCES IN THE REGION OF THE HEEL

PAINFUL HEELS

Causes.—There are several causes of painful heels. The most important are local irritations by the heel and counter of the shoe. There are also systemic causes.

More often than otherwise there is no demonstrable spur at the time the person first complains of painful heels.

Possibilities

1. No spur
2. Spur not yet radiopaque
3. Bursa
4. Periostitis
5. Apophysitis
6. Osteitis
7. Tuberculosis
8. Osteomyelitis

Irritation from

1. Counter of shoe, (construction, material)
2. Lining
3. Ridges
4. Injury

Bulges on bone may be (1) new ones, (2) aggravation or accretion of old ones. Bone blisters produce knuckle-like prominences covered by periosteum that is stretched. Soft tissues are stretched, pressed upon, rubbed against and compressed. When the tissues are sandwiched between the rigid bone and the rigid counter of the shoe, it produces irritation, pressure and pain. Constant pressure produces ulceration, intermittent pressure produces hypertrophy.

Treatment.—Treatment includes local and general measures.

1. Remove counters.
2. Remove entire back of heel of shoe.

Policeman's heel is often a persistent painful condition, and often requires a good deal of patience to effect a cure. Raising the heel, rubber sponges, felt pads fitted under the arch with a depression for the heel, cutting out the center of the heel of the shoe, or a steel plate supporting the arch with the heel cupped, are suggested as remedies. Spurs may have to be removed in resistant cases.

The chief conditions occurring in the region of the heel may be divided into those affecting the os calcis and those involving the soft tissues. They include exostoses or spurs, osteitis, osteomyelitis, apophysitis, bursitis, fascitis, tendonitis, and blisters. These conditions are discussed in their respective chapters.

The important causes of painful heels are injury, infection, static defects, and metabolic disorders.

Blisters on the heel are due to irritation from footwear and must be treated aseptically to prevent infection.

Infections of the Os Calcis.—Infections are caused by the streptococcus, staphylococcus, gonococcus, and the organisms of tetanus and gas gangrene. A pyogenic infection produces a serious inflammatory reaction with destructive osteitis. Osteomyelitis of the os calcis is best treated by the Orr method and chemotherapy. Gaenslen's split-calcaneus approach is recommended. (Fig. 255.)

Tuberculosis of the os calcis which is described in Chapter XXI usually affects the anterior portion of the body of the bone. The treatment of isolated disease of this bone is incision and evacuation and later subastragalar arthrodesis.

CALCANEAL SPURS

Calcaneal spurs occur most frequently in the inferior-medial aspect of the bone. Their next most frequent location is the posterior superior surface. (Fig. 169 and 170.)

Etiology.—Calcaneal spurs are due to various causes such as: (1) focal infections with the ordinary cocci or other bacteria; (2) metabolic disturbances, especially of gastro-intestinal and gallbladder origin; large numbers of cases are seen in which the metabolic factor is either the most important or an element in the exaggeration of other factors; (3) trauma due to injury and improper shoes; (4) static conditions such as flat-feet; and (5) a short plantar fascia. The term "gonorrheal heel" is a misnomer.

The plantar fascia takes its origin from the tuberosity of the os calcis. If pressure is applied to this area or if the plantar fascia pulls on its attachments, a slight separation or pulling off of the periosteum at this point will result. Under the stimulation of trauma or infection, or both, osteogenesis occurs more actively and a vicious cycle is established. As the periosteum separates, proliferation of the osteogenetic layer occurs and new bone, resulting in the production of a spur, is formed.

Symptoms.—The symptoms of calcaneal spurs are pain, tenderness, swelling, and limp. The onset is usually gradual unless the cause is an infection such as acute arthritis, when it may be very acute. The pain and tenderness are usually along the medial border of the os calcis or at the attachment of the plantar fascia.

Some patients with painful heels, especially those with spur formation, are most comfortable in walking upstairs because they walk on the balls of their feet. The roentgenogram may or may not reveal a

bony spur, depending on the duration of the pathological condition and the density of the spur In many cases of very painful heels the roentgenograms reveal no spurs The degree of trouble is not determined by the size of the spur

Diagnosis —The differential diagnosis rests between bursitis, osteoma, flat-foot, and arthritis

Prognosis —The prognosis for complete relief is good if the spur is the only cause of the trouble If there is an arthritis of the foot, removal of the spur will not give sufficient relief Most patients can be made comfortable without operation, others are not cured by surgery Symptoms and spur formation may recur in the same or the other foot Failure to relieve the pain may be due to a local bursitis

Treatment —**Non-operative Treatment** —Causative factors, such as the residue of a gonococcus infection, or infected tonsils or teeth, should be treated if they can be found The gastro-intestinal condition should be relieved Weight-bearing should be discontinued, and bed treatment with the application of an anodyne lotion plus fomentations should be given An excellent lotion is given on page 402

After all pain and most of the sensitiveness have disappeared, plaster-of-Paris casts should be applied After from two to four weeks proper shoes should be prescribed High-laced shoes made on a straight last and with a round toe are advisable The shank should be of medium width and at first, rigid Felt pads should be inserted in the shoes to relieve weight-bearing on the painful areas The heel of the shoe should be entirely removed and replaced with a low heel of rubber One of my patients hit on an unusual method of treating his painful heels He pounded his bare heels with the flat side of a hammer daily for many months with remarkable relief temporarily The x-ray is often effective

Operative Treatment —Operative treatment consists in removal of the spur Operative trauma often stimulates osteogenesis, especially if the infectious or causative agent is still present The size of the spur is not the determining factor The incision should be made along the inner or outer border of the heel The removal of the spur is accomplished by means of a chisel and mallet After the operation, a plaster cast should be applied and left on for about ten days

A precalcaneal fasciotomy can be performed with relative ease and gives better results than the usual method of stripping the plantar fascia from the os calcis and removing the spur

The postoperative care consists of relief from weight-bearing by means of proper shoes containing weight-relieving felt pads In cases with metabolic disturbances regulation of the diet is important When the patient is obese, meat, eggs, fish, and sweets are usually contraindicated Diathermy is beneficial for an accompanying arthritis

It is not advisable to remove calcaneal spurs unless they are the cause

of the patient's complaint or unless it is believed that removal of the spur will make the foot comfortable.

Exostoses may form on other parts of the os calcis, especially the postero-superior rim or the medial and lateral edges. Removal of the counter of the shoe is usually sufficient to give relief, but occasionally resection of the exostosis or plantar fasciotomy is necessary.

FIGS. 169 and 170 —Roentgenograms showing well-developed calcaneal spurs Note sclerosis of posterior tibial artery on right. (Lewin, courtesy of Arch. Surg)

Retrocalcaneal Exostoses.—Retrocalcaneal exostoses are due to irritation, usually from the counter of the shoe. As a rule, they should be treated by removal of that structure and elevation of the heel. However, some of them reach such a size and produce so much discomfort that their resection is necessary.

Lateral exostoses of the os calcis due to irritation from the counters of shoes are frequently observed in adolescent children. If they remain troublesome after a reasonable period of wearing counterless shoes, operative removal is advisable.

Many substances have been injected to relieve painful heels. Some of these patients have calcaneal spurs, others do not. An important consideration is the relationship of calcaneal bursitis to painful heels, since many patients who complain of painful heels have calcaneal bursitis.

There is no doubt that injection treatment has often resulted in relief, but in some cases it has made the pain worse. One must realize that any injection in and around the periosteum of a bone is apt to cause considerable pain. Many of the cases that have been relieved by injection were relieved by the infiltration of the spur-bearing area,

in which there may be a bursa By relieving the bursitis, injection with novocain may prove of some merit

Many cases of painful heel are due to bursitis in the region of the attachment of the plantar fascia to the os calcis In some of them there are demonstrable exostoses One of the best methods of relief is the removal of the counter or the entire back of the shoe (Fig 174)

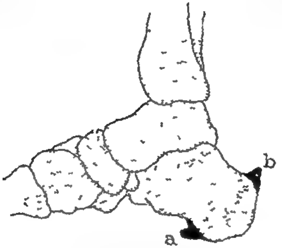


Fig 171 —Exostosis of os calcis with (a) ordinary calcaneal spur and (b) exostosis at posterior-superior angle

Apophysitis of Os Calcis —According to Meyerding and Stuck, an important factor in the development of apophysitis of the os calcis is the common modern practice of robust boys who engage in vigorous games in heelless athletic shoes The undue strain on the calcaneal epiphysis during the period of greatest growth of the bones engenders an appreciable amount of epiphyseal change that is never discovered Destructive changes in the epiphyses of the heels are common among young, vigorous children, and failure to recognize them depends on absence of symptoms and consequent neglect in obtaining roentgenograms

Apophysitis of the os calcis is discussed on page 261, and fracture of the os calcis on page 331 Tuberculosis and osteomyelitis of the os calcis are discussed on pages 429 and 437

PERIOSTITIS OF THE OS CALCIS

The causes of periostitis include infections, injuries from shoes, metabolic disturbances, and obesity Periostitis of the os calcis may involve the lateral, posterior, or inferior surfaces It is due to infection or to trauma or friction caused by the counter of the shoe Lateral *periostitis* may occur from irritation of the shoe or infection plus irritation The periosteum is thickened and edematous and may be raised from the

bone. The symptoms are pain, tenderness, and swelling. The treatment consists of removal of the counter of the shoe, as much rest from weight-bearing as possible, and local heat and massage. When indicated, general treatment may be given. Potassium iodide has been recommended.

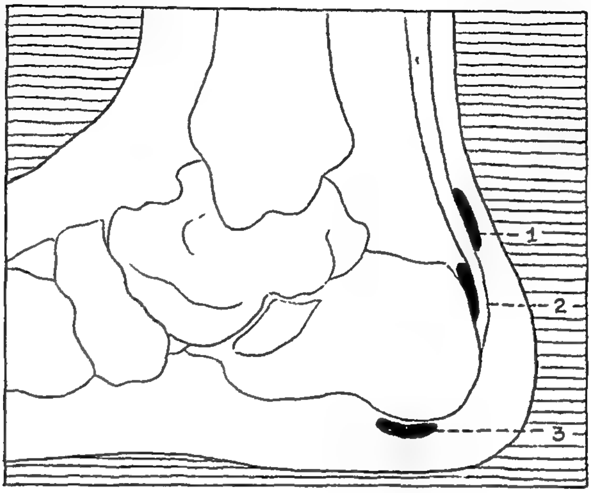


FIG. 172.—Bursæ in the region of the heel. *1*, Retro-achilleal; *2*, retrocalcaneal, *3*, subcalcaneal (Courtesy of A R. Shands, Jr., and C V Mosby Company)

BURSITIS IN THE REGION OF THE HEEL

The calcaneal bursa lies between the tendon of Achilles and the posterior surface of the calcaneus, but an adventitious bursa frequently

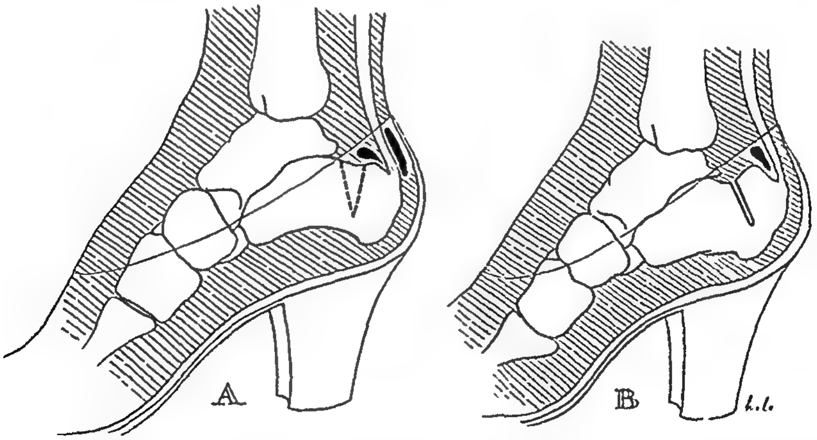


FIG 173.—Achillobursitis *A*, Relationship of the bursæ to the os calcis and to upper quarter of patient's shoe Shows how wedge is removed from the os calcis *B*, After operation, showing the wedge closed and the superficial bursa removed (Redrawn from Zadek, courtesy of Am. Jour. Surg)

arises in a subcutaneous position and immediately overlying the point of insertion of the tendon. Both bursæ, but particularly the latter, are liable to irritation by ill-fitting shoes. If the overlying skin becomes

blistered or broken, a lymphatic infection of the bursal space ensues

Bursitis at the point where calcaneal spurs are usually found may be responsible for the symptoms attributed to a spur seen in the roentgenogram Removal of the bursa will relieve the pain X-ray therapy is effective If the spur alone and not the bursa is removed, the pain may persist

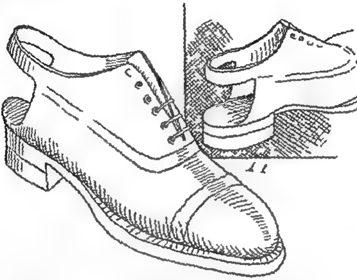


FIG 174 —The removal of most of the back of the shoe to relieve pressure on the heel and Achilles areas (Redrawn from Burns and Ellis Recent Advances in Orthopædic Surgery courtesy of J and A Churchill Ltd)

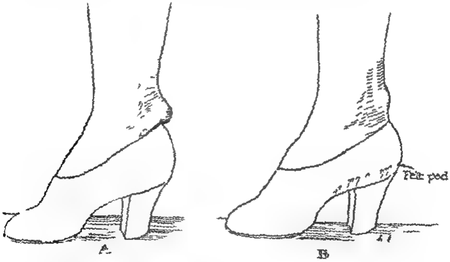


FIG 175 —Bursitis of the heel A Note relation of counter of shoe to tumor mass B Comfort obtained by application of felt pad in heel

Achillobursitis —Achillobursitis or inflammation of the bursa between the Achilles tendon and the os calcis is usually caused by infection or trauma from the shoe (It has been called "cathedral heel" because it occurred in American sightseers in Europe) It may require operative removal

Bursitis between the Achilles tendon and the skin is superficial and usually due to irritation of the shoe. (Fig. 175.) It is frequently worse in winter and bears some analogy to chilblains and trench foot. Rest, elevation, and local applications for a few days should be beneficial. During this period the counter or the entire back of the shoe should be removed. Elevation of the heel may afford considerable relief. X-ray may be effective Attention to the footwear may afford relief, but if a definite infection of the bursa is established, it is advisable to remove the sac and take precautions against the recurrence of the irritation.

Zadek's operation for the relief of achillobursitis is based on the bony changes underlying the bursa, resulting in a spur of the os calcis projecting posteriorly. Removal of the posterior bony projection at the top of the os calcis is essential for cure.

AVULSION OF THE HEEL

Avulsion of the heel may be caused by a heavy glancing blow applied directly to the heel or by crushing of the posterior part of the foot. The forces may be of sufficient strength to produce fracture of the os calcis as well.

While not a common accident, it is not a surgical rarity in industrial hospitals. It may produce a serious condition. When ulcers of the heel are formed they are disabling and usually resistant to therapy.

Colp advises thorough cleansing and careful débridement of the wounded heel and replacement of the tissues by accurate suturing. In a great many cases, healing will occur by primary union. In some cases, however, the torn tissue will subsequently become gangrenous and slough away. If the area is small and superficial, healing may occur by secondary intention, but if the resulting scar is adequately protected, it may never cause trouble. When the heel is completely torn away or secondary gangrene has resulted from exposure of the Achilles tendon and part of the os calcis, immediate treatment is imperative.

CHAPTER XII

BONES OF THE FOOT AND ANKLE

PRIMARY BONE REACTION

Bone reacts to the following factors, singly or in combination heredity, trauma (injury, operation), infections, metabolic disturbances, neoplasms, circulatory disturbances, foods, vitamins, ultra-violet rays, muscle disturbances, endocrine disorders, exercise, neurogenic lesions, metals, disuse, immobilization, and miscellaneous influences

The most important causes of demineralization are injury and infection immobilization, disuse, starvation and neurogenic lesions

OSTEOPOROSIS

Osteoporosis is caused chiefly by injury, infection, and disuse The bones show loss of lime and appear dark in the roentgen negative The symptoms are pain, tenderness, and disability The treatment includes local and general measures The former are physical therapy such as the whirlpool and hot paraffin baths, contrast plunges, and sympathectomy The general measures are the administration of calcium by mouth and by vein, parathyroid operations, and irradiation

The most important bone dystrophies are dwarfism, achondroplasia, syphilis, and osteogenesis imperfecta

Post-traumatic Painful Osteoporosis—The chief modifications of the bony structure produced by trauma are active vasodilatation, rarefaction, condensing osteitis, osteophyte formation and osteoporosis Leriche believes that active vasodilatation, by impairing the nutrition of the connective tissues, produces osseous rarefaction This is one of the fundamental laws of osseous biology This hyperemic rarefaction is one of the basic factors necessary for the union of fractures It also leads to traumatic osteoporosis, Sudeck's disease, and all those conditions called osteo-articular diseases of a vasomotor origin Under the influence of the circulatory disturbances that frequently follow injury, the bones of the foot and ankle undergo rapid and extensive physicochemical changes Leriche made a complete study of post-traumatic painful osteoporosis and reported some of the striking benefits obtained from operations upon the sympathetic nervous system

Osteoporosis is quite common after trauma to the periarticular or juxta-articular regions with or without fracture Its frequency after trauma to the periarticular regions of the ankle suggests that it is due to stimulation of the numerous articular and periarticular nerves, which causes vasomotor changes

Marked osteoporosis may follow a very slight trauma to the soft tissues. It has been shown that the peripheral vascular disturbances associated with spasm of the surrounding muscles give rise to osteoporosis in the great majority of the cases. Leriche and Policard have demonstrated that hyperemia is necessary for the absorption of bone. Fontaine and Herrmann are of the opinion that true osteoporosis is the direct result of the hyperemia produced by vasomotor changes resulting from reflexes originating in the traumatized area.

Osteoporosis is found most frequently in the short bones of the feet; next most frequently, in the epiphyses of the metatarsals, metacarpals, and phalanges; and next most frequently in the epiphyses of long

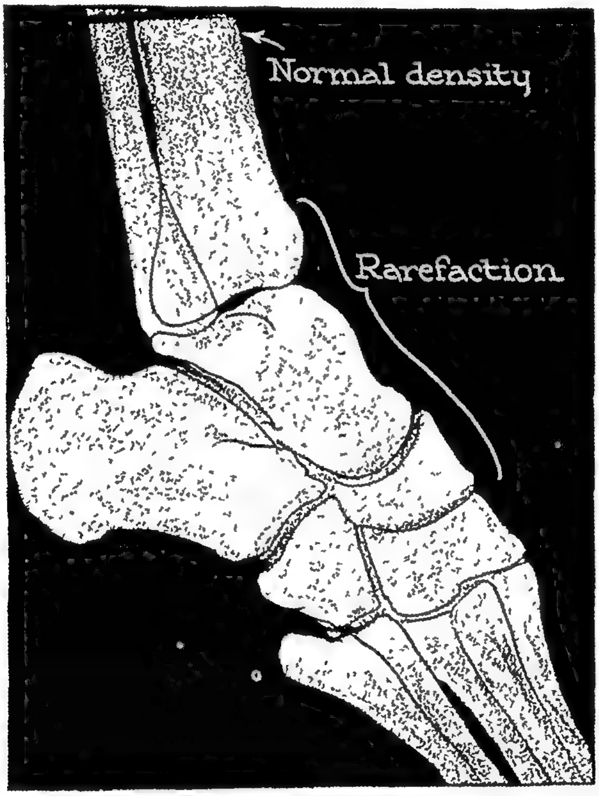


FIG. 176—Osteoporosis of ankle bones and their contiguous bones due to pyogenic infection. (Redrawn from roentgenogram.)

bones. The diaphyses of long bones are rarely involved. Fontaine and Herrmann distinguish four main forms of painful osteoporosis, namely: (1) the post-traumatic form, (2) the post-infectious form, (3) the form associated with nervous disorders, and (4) the dystrophic form associated with disturbances of ovarian function.

True osteoporosis is characterized by: (1) loss of motor function of the extremity, (2) characteristic changes in the roentgenograms (see Fig. 176) (3) the constant co-existence of vasomotor disturbances,

and (4) severe pain which is not relieved by immobilization or physical therapy

Acute and chronic forms of osteoporosis were described by Sudeck. The acute form is characterized by a mottled appearance of the bone due to the irregular rarefied areas in the spongiosa.

The three stages in the evolution of the lesion are the onset, the height of the disease, and the reorganization.

After the disease has reached the climax or stage of complete decalcification, the process of recalcification begins spontaneously. In untreated cases, the recovery of function of the extremity requires many years, and extensive fusion of the tarsal bones frequently takes place during the stage of recalcification.

In cases in which the injury of the articular or periarticular tissues is associated with a fracture, the trauma is considered the major cause of the pain and local vasomotor changes. Since such injuries are routinely treated by complete immobilization in splints or plaster-of-Paris casts, it is always necessary to consider the possibility of atrophy due to inactivity. Whenever an extremity continues to show evidence of vasomotor disturbances associated with limitation of movement and pain in the neighboring or involved joints after proper reduction of the fracture, the most probable cause of the disturbance is a diffuse osteoporosis, and roentgenograms should be taken at once.

Massage and voluntary motion of the joints can be carried out in spite of a little pain, but forceful manipulation under anesthesia is definitely contraindicated. Any form of fixation with plaster-of-Paris casts or apparatus causes increased pain. DeLorme recommended thyroid and parathyroid extracts, and Pech advised heliotherapy.

The first periarterial sympathectomy for osteoporosis was performed by Heymann, in 1924. Periarterial sympathectomy is usually sufficient for cases of post-traumatic osteoporosis which is limited to the distal part of the extremity. Lumbar sympathetic ramisection should be reserved for the severe form of the condition.

Sympathetic nerve block with procaine offers relief in many cases and is a good index of what can be expected from sympathectomy.

In cases of severe pain that precludes active physical exercise, sympathetic nerve block should be tried.

CHAPTER XIII

DISTURBANCES OF THE EPIPHYSES OF THE FOOT AND ANKLE

THE epiphysis is that part of the bone which is concerned with its growth. At each extremity of the body or shaft of a long bone there is a layer of cartilaginous tissue called the "epiphyseal cartilage" which persists as a separate entity for a definite period. At the end of that period, longitudinal growth ceases.

The periosteum is an important bond between the epiphysis and the diaphysis. The articular cartilage is the only part of the epiphysis that does not unite and become bone.

The functions of the epiphyses are to serve in the formation of joints; to afford points of attachment for muscles and tendons; and to develop the length of the bones.

The usual appearance of centers of ossification for the tarsal bones is as follows: posterior extremity of the os calcis, tenth year; cuboid, ninth month; astragalus, seventh month; scaphoid, fourth year; internal cuneiform, third year; middle cuneiform, fourth year; external cuneiform, first year.

Epiphyses obtain their blood supply from the network of periosteal arteries, branches of which perforate the compact bone to be distributed throughout the cancellous bone.

The most important epiphyseal disturbances of the foot and ankle are epiphysitis at the lower ends of the tibia and fibula, apophysitis of the os calcis, Köhler's tarsal scaphoiditis, Freiberg's infraction of a metatarsal head, epiphysitis of the base of the fifth metatarsal, and separations at the lower ends of the tibia and fibula.

The causes of epiphyseal disturbances include heredity, circulatory changes, infection, diet, muscular effort, ligamentous strain, constant pressure, trauma, endocrine disturbances, and obesity.

Symptoms.—The symptoms of epiphysitis are pain, swelling, tenderness, limp, and limitation of movement.

The roentgenographic findings in the epiphyses are changes in shape, size, and radiability. The most common late finding is a condensing osteochondritis.

Diagnosis.—In the differential diagnosis it is necessary to exclude tuberculosis, fracture, dislocation, pyogenic infection, syphilis, and rickets.

Prognosis and Course.—Except in cases of acute septic epiphysitis, the prognosis is usually good as far as recovery of function is concerned,

but less favorable with regard to the restoration of the form of the epiphysis Weight-bearing is important in the production of deformity

Treatment —The treatment of epiphyseal disorders includes general and local measures The former are determined by the general condition, and the latter are directed to the epiphyses In general, the local treatment consists of rest, immobilization, support, and relief from weight-bearing Plaster-of-Paris casts, splints, braces, and operations are often indicated In various conditions, phototherapy, heliotherapy, active and passive movements, and massage are of value

Fig 177 —Normal epiphyses of the foot and ankle at puberty (Sullivan Geist and Mueller courtesy of Jour Bone and Joint Surg)

OSTEOCHONDRITIS OF THE LOWER ENDS OF THE TIBIA AND FIBULA

In 1922, Stern demonstrated a case of osteochondritis of the lower ends of the tibia and fibula, and in 1928, Ritter reported a typical case of this condition in the lower end of the tibia

APOPHYSITIS OF THE OS CALCIS

Apophysitis of the os calcis, first described by Sever, is an inflammation of the caplike epiphysis of the posterior portion of the heel bone It occurs usually in boys between the ages of nine and thirteen years It is analogous to Kohler's tarsal scaphoiditis and Freiberg's infraction of the metatarsal head, but particularly to Osgood's tibial epiphysitis Its probable causes are external and internal trauma, especially the latter, and local circulatory disturbances affecting the epiphysis during a vulnerable period in its growth and development

A definite history of injury is not constant The child may merely have been running on hard pavements, wearing sandals or tennis shoes The first symptoms are usually a limp and a dull pain The

pain is less marked while shoes with heels are worn. Pressure by the shoe aggravates it. Signs of acute infection are not prominent. Tenderness may be present over the posterior aspect of the heel and the region of the Achilles tendon. This accounts for the equinus position of the foot and the limitation of dorsiflexion. There is a disinclination to complete the full step. Pronation may be present.

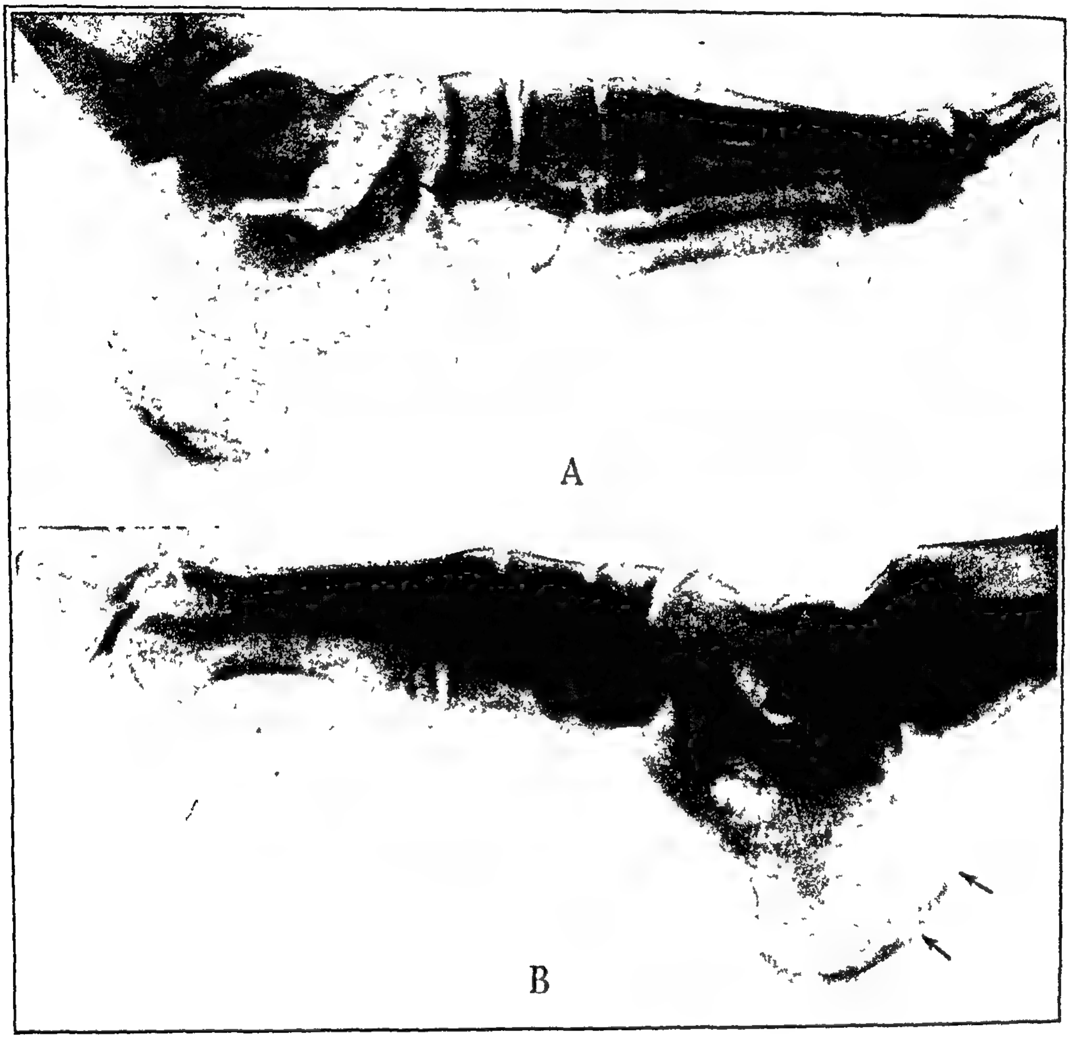


FIG 178 —Apophysitis of os calcis *A*, Normal *B*, Fragmentation.

Roentgenograms made in anteroposterior and lateral projections may reveal irregularity of the apophysis with thickening, clouding, or partial obliteration of the epiphyseal line. The epiphysis may be fragmented (see Fig. 178).

In the differential diagnosis it is necessary to consider achillobursitis, tenosynovitis, bursitis between the tendon of Achilles and the skin, calcaneal spur, tuberculosis, and pyogenic infection.

Prognosis.—The prognosis is excellent if proper orthopedic treatment is instituted. The course varies from a few weeks to several months. The condition may recur as a result of overactivity or trauma.

Treatment.—The indications are to relieve the tendon of Achilles of strain and prevent weight-bearing on the os calcis. In mild cases it is sufficient to elevate the heel, remove the counter of the shoe, and insert a pad of felt or sponge rubber in the heel. Burns and Ellis remove the entire back of the shoe (see Fig. 174). A rear end tongue and lacings is effective in relieving the area of pressure. The heel may be protected by adhesive strapping and correction of the pronation. Rubber heels should be worn.

The most satisfactory treatment of an advanced case is the application of a plaster cast extending from the toes to just above the knee in such a manner as to hold the foot in slight equinus to relax the pull of the triceps surae muscles with the knee in slight flexion. A walking iron may be attached. Crutches should be used.

After two weeks this cast should be replaced by another extending from the toes to the garter line and holding the foot at a right angle, but with no varus or valgus. At the end of four more weeks, the second cast should be removed, and the patient should wear a high-laced shoe with a $\frac{3}{4}$-inch inside lift of cork for the heel. During the next two weeks, weight-bearing should be relieved with crutches, and contrast baths, baking and inductotherm should be employed.

Throughout the course of treatment the importance of direct sunlight and proper food should be emphasized. If a glandular disturbance is present, appropriate therapy should be instituted to correct it.

KOHLER'S TARSAL SCAPHOIDITIS

Kohler's tarsal scaphoiditis is characterized by pain which is exaggerated by weight-bearing. It occurs most frequently in children between the ages of four and ten years. It is more common in boys than in girls. Its cause is unknown. By some, it is believed to be a congenital anomaly, by others, the result of infection or injury. It is a compression osteochondritis.

The chief signs are found in the tarsal scaphoid bone, which is sensitive to movement and tender to pressure. The patient limps and bears weight on the outer border of the foot to relieve the inner border. The diagnosis is confirmed by the roentgenograms, which reveal a narrowing of the scaphoid from front to back and condensation of the nuclear bony structure. In the lateral view the scaphoid may look like a silver half-dollar seen on edge. (See Fig. 179.)

The initial treatment is the application of a plaster cast to hold the foot in slight varus and the use of crutches to prevent, or a walking

iron to permit, weight-bearing. After a few weeks the ankle and mid-tarsal regions are strapped with adhesive tape and the patient wears a high-laced shoe with a Thomas heel and felt pads to relieve the strain on the longitudinal arch structures. Later, flat-foot exercises, gentle massage, and contrast baths are prescribed. It is advisable to investi-

Fig. 179 —Kohler's tarsal scaphoiditis.

gate for foci of infection, especially in the tonsils. If such foci are found, they should be removed. Complete regeneration of bone may require several years. Several cases of osteochondritis of the cuneiform bones have been observed.

JUVENILE DEFORMING METATARSOPHALANGEAL OSTEOCHONDRITIS

Freiberg's Infraction of a Metatarsal Head

This lesion was described by Freiberg in 1914 and by Köhler in 1915. I have seen at least 20 cases and have added the terms "metatarsal epiphysitis" and "juvenile deforming metatarsophalangeal osteochon-

dritis" The cause of the lesion is trauma affecting bone and cartilage during a period of unusual growth. The important factors are trauma, circulatory disturbances and infection. The forcible impact of the ball of the foot against the ground, especially during athletic activities, will cause the distal ends of the second or third metatarsal bones to bear the brunt of the blows.

Freiberg's infraction of the metatarsal head occurs most frequently in girls during adolescence. Union of the metatarsal diaphysis and epiphysis occurs between the eighteenth and twentieth years of age, and union of the phalangeal structures at about the eighteenth year.

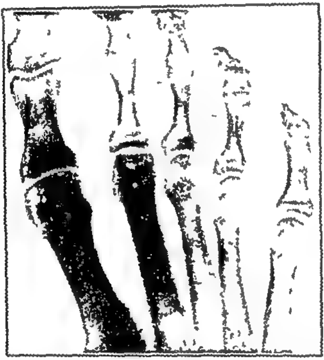


FIG. 150.—Freiberg's infraction of metatarsal head. Roentgenogram of foot showing flattened second metatarsal head, broad neck and head, increased joint space and triangular shaped area of epiphysis. (Sometimes called Köhler's second disease.)

The second, third, fourth, and fifth metatarsal bones are each ossified from two centers: one for the body and one for the head. The first metatarsal has one center for the body and one for the base. Ossification begins in the center of the body. It is probable that when infraction of a metatarsal head is found in an adult it was present but unrecognized in earlier life.

The gross pathologic changes consist of flattening of the metatarsal head, with broadening of the neck and distal portion of the shaft and irregularity of the epiphyseal line.

There is pain in the region of the affected metatarsal head. Swelling is usually present. There is sharply circumscribed sensitiveness to pressure over the metatarsal head and the metatarsophalangeal joint. Limitation of movement is present. Abscess formation is very rare.

The following roentgen-ray findings are characteristic: (1) flattening of the metatarsal head; (2) broadening of the neck and distal portion of the shaft; (3) irregularity of the epiphyseal line; (4) widening of the metatarsophalangeal joint space; (5) diminished cupping of the articular surface of the proximal phalanx; and occasionally, (6) a line of incomplete fracture without displacement. Valentin, Axhausen, and Liek found areas of sequestration similar to those observed in the cases I reported.

It is advisable to have roentgenograms made of both feet of every child with a persistent metatarsalgia. If the first film is negative, the examination should be repeated after a few weeks.

The differential diagnosis rests between Morton's metatarsalgia, Deutschländer's metatarsal periostitis, fracture, dislocation, syphilis, and arthritis of childhood. Deutschländer's metatarsal periostitis is

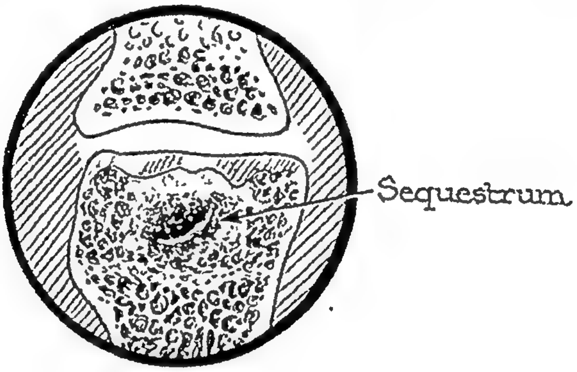


FIG. 181.—Freiberg's infraction of a metatarsal head.

a subacute inflammatory periostitis in which there is local tenderness at the junction of the middle and distal thirds of the metatarsal shaft and roentgen-ray examination reveals evidence of periostitis.

The course of Freiberg's infraction of the metatarsal head lasts a few weeks. Recurrences have occurred after non-operative treatment, but all cases in which operation was performed have been reported cured.

In the treatment, the affected foot should be entirely relieved of weight-bearing by means of crutches and a block under the heel and sole of the shoe of the other foot. It should be immobilized in a plaster cast with a small, beveled, felt pad applied just back of the metatarsal heads. As the cast sets, pressure should be applied laterally and upward to build up the metatarsal arch.

When all symptoms have disappeared, a proper shoe should be prescribed and a felt pad inserted for the transverse arch. A metatarsal bar or crescent is advised. The entire leather heel should be removed and a low rubber heel applied. Heliotherapy, hyperemia, and hydrotherapy are indicated. Baking, gentle massage, and passive

and active movements with contrast baths will hasten recovery. After the acute stage has passed, special exercises for the metatarsal arch should be performed cautiously.

When conservative treatment fails or when there is considerable pain and the roentgenogram shows a sequestrum or loose bodies, operation is advisable.

OSTEOCHONDRITIS OF THE BASE OF THE FIFTH METATARSAL BONE

Pain in the region of the base of the fifth metatarsal bone may be due to grazing of the affected area by an automobile wheel. The diagnosis is traumatic epiphysitis. Roentgenograms may reveal absence of the epiphysis.

A plaster-of-Paris cast should be applied while the ankle is held in a position of eversion and the forefoot in abduction, to relax the pull of the peronei brevis and tertius muscles. After two weeks this cast may be removed and the shoe modified by the application of a reversed Thomas heel, a wedge along the outer border of the sole, and the insertion of a beveled felt pad to relieve the longitudinal arch of mechanical strain. Complete recovery may be expected after about eight weeks.

ACUTE INFECTIOUS EPIPHYSITIS

Acute infectious epiphysitis is analogous to acute osteomyelitis. It is a hematogenous infection. The epiphyseal disk is a strong barrier against the spread of infection from the diaphysis. Any one of the numerous epiphyses may be infected, but the most common are at the posterior portion of the os calcis and the heads of the second and third metatarsals.

TRAUMATIC EPIPHYSITIS

Traumatic epiphysitis includes separation, separation and displacement, and fracture of the epiphysis. Any one of the epiphyses may suffer acute or chronic trauma, but the most common are at the scaphoid, heads of metatarsals, base of fifth metatarsal and apophysis of the os calcis. One of the most serious epiphyseal injuries is the one produced in the region of the external malleolus by violent manipulations of club-feet, which may cause considerable deformity and disability in later life.

CHAPTER XIV

EXOSTOSES AND ACCESSORY BONES OF THE FOOT

Exostoses or bony outgrowths occur chiefly on the head of the first metatarsal, the os calcis and the phalanges. Removal of these outgrowths is called exostectomy.

Exostoses of the foot are especially prone to develop on the heads of the first and fifth metatarsals, the os calcis, the upper surface of the first cuneiform, and the phalanges, but may occur on any bone of the foot. The most important are those formed on the head of the first metatarsal in connection with hallux valgus and bunion; those occurring on the head of the fifth metatarsal, the so-called bunionette; those occurring on the phalanges; the subungual exostoses; and the so-called "overbone" which, in many cases, is not a true exostosis but is due to a subluxation at the metatarso-cuneiform I joint. Aside from the exostoses occurring on the head of the first metatarsal, those found on the os calcis have received most attention. The exostoses on the os calcis are found in practically every location, but especially on its inferior-medial surface, its inferior surface, and in the posterior portion, above, medially, and below. The relationship of exostoses to bursæ and bursal sacs and bursal inflammation is very close. Many of the bursæ occur in the regions of exostoses, where they are due to irritation. The bursal sac is sandwiched between a hard surface, like that of a bone, and a rigid surface, like the counter or some other part of the shoe. This is true especially in the first metatarsophalangeal joint, in the heel, and the region of the base of the fifth metatarsal bone.

Exostoses occurring on the phalanges between the toes are important in cases of soft corns. An exostosis of the first metatarsal head may occur on the medial or the lateral sides, the top, or the bottom. Sometimes an overgrowth of bone acts like a collar around the head of the bone. Such formations are usually due to irritation or injury. While many of them require surgical excision, some can be relieved temporarily by cutting the shoe and applying what is known as a "patch pocket."

Exostoses occurring under the nails are discussed below, and calcaneal exostoses are discussed on page 250.

"OVERBONE"

An "overbone" is a prominence over the dorsum of the foot. Such a prominence is common in a foot with a high longitudinal and a low transverse arch. The mechanism of its production is subluxation at

the first metatarso-cuneiform joint in which one of the edges becomes prominent like a knuckle (Fig 182) The primary factor is a bony prominence The secondary factors are a bursa, a ganglion in the tendon sheath, and irritation of a vein The extensor hallucis longus tendon, which passes over this area like a rope over a rough edge, becomes irritated by the lacings of the shoes Therefore, in lacing the shoes the eyelets in the vicinity of the prominent bone should be skipped The best non-operative treatment is the wearing of a high-laced shoe so that several of the eyelets can be skipped, padding for the transverse arch to minimize the prominence of the bone by bringing

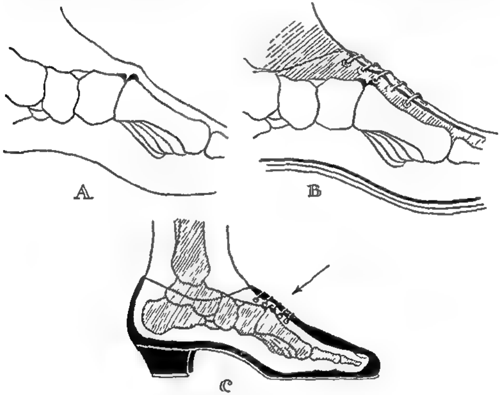


Fig 182 — Overbone —prominence over dorsum of foot in region of base of metatarsal I Arrow indicates relation of eyelet of shoe to prominent bone The proximity of extensor hallucis longus tendon is not shown

the transverse arch into better alignment with the mid-tarsus, padding of the tongue of the shoe, and the application of a metatarsal crescent to the sole of the shoe

In Summary One Should
1 Remove eyelets 2 Reroute laces 3 Insert metatarsal pad 4 Add metatarsal crescent 5 Pad tongue

Operation, which is frequently necessary, consists of an elliptical incision and chiseling off of the exostosis, together with the removal of any bursa or ganglion which may be present.

Prominent, Painful Scaphoid Bone.—An unusually prominent scaphoid bone is often found in persons with pronated, flat feet. In some cases it is due to a congenital maldevelopment, while in others it develops from weight-bearing on pronated feet. It gives the impression of an "accessory medial malleolus." Its prominence results in irritation of the overlying skin with redness and pain. Relief can be afforded by removing the pressure of the shoe over the prominence, and tilting the heel laterally by adding $\frac{3}{16}$ inch or more to the medial border. Excision of the prominent portion may be necessary.

SUBUNGUAL EXOSTOSES

Subungual exostoses are irritative, warty overgrowths of bone occurring beneath the nails as solitary, benign, slowly growing, painful tumors, appearing as fibrous nodules the size of peas, almost invariably beneath the inner or tibial margin of the terminal phalanx of either great toenail. They arise from a cartilaginous outgrowth from the inner, middle portion of the distal phalanx of the great toe and become osseous. Their attachment to the phalanx is usually complete or osseous, but may be partial or fibrocartilaginous. They are three times as common in women as in men. They arise most frequently between the ages of twelve and thirty years. They may be readily confused with granuloma pyogenicum, ingrowing nail, simple fibroma, or malignancy.

Subungual exostoses are usually due to old injuries that may have been forgotten, a mild periostitis or osteitis, or a recent injury. They probably represent a teratologic anomaly, although trauma may be a factor precipitating their growth. They arise from the periosteum, beginning as an acute periostitis, later becoming subacute and then productive, until bone is fully formed. There is little about the firm fibrous nodule, which in the early stages of the disease is pink and later becomes keratotic, to suggest the underlying exostosis.

Roentgen examination is diagnostic except in early immature growths.

The accepted method of treatment is surgical incision. In order to prevent recurrence the growth must be removed completely. The "fishmouth" incision is a satisfactory approach.

In the *Kurtz operation,* a constrictor is placed about the base of the toe and clamped. After blocking of the nail with novocain, the needle is passed well under the growth from the front until the bone is reached, more novocain being deposited. The nail over the growth is cut away until the full length of the growth is exposed. The growth may be

peeled from its bed Trimming of the edges of the cavity is then done, the cavity painted with pure phenol followed by alcohol, and the tourniquet removed Oozing is controlled by pressure, and wet dressings are applied The author uses the "fishmouth" incision, which passes through the middle of the end of the toe, parallel with its long axis

Many years ago I described an instrument which I named a *bunion dissector* Later I stated that this instrument could be used as a sesamoid remover I have since found that this instrument is the best I have ever used to remove toenails It is slipped under the nail, and by gently prying, the entire nail is lifted from its bed in a simple atraumatic manner

While this operation may not be a common one in the practice of most orthopedic and traumatic surgeons, when it does come up it is important to have the best instrument

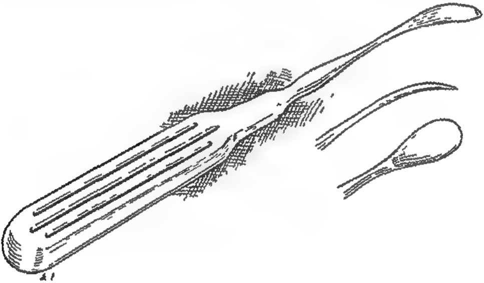


FIG 183 —Author s instrument useful as a toenail elevator a sesamoid dissector, and a bunion dissector

---

ACCESSORY BONES OF THE FOOT

SESAMOIDS

The sesamoids of the feet are shown in Figure 184 The most important sesamoids are found on the plantar surface at the base of the big toe joint The lesions are fracture, *dislocation, contusion,* chondritis, sesamoiditis, and sesamoidosis

The traumatic lesions are especially important In dancers and athletes, the sesamoids most commonly injured are those at the base of the big toe These sesamoids, which have been believed to cause hallux valgus and calluses, are often removed surgically

The sesamoids in the flexor hallucis brevis tendons are subject to much stress and strain, especially in stepping or jumping from a height or while dancing. Often the roentgenogram will reveal a divided sesamoid resembling a fracture. Many sesamoids of this type are developmental anomalies which are especially susceptible to trauma. A bipartite sesamoid is analogous to a bipartite patella. As a rule, relief from weight-bearing by means of felt pads and a metatarsal shoe crescent will afford comfort, but occasionally removal is necessary.

Fractures of the sesamoids of the big toe are usually due to direct violence such as jumping, stepping off stairs with the toes in extreme hyperextension, falling from a height, hitting the foot against a rock in swimming, dancing and skating accidents, catching the foot in a hole, or the impact of a heavy object on the foot. The indirect type of fracture is produced only when the trauma causes a sudden hyperextension of the toe, followed by a tightening up of the adjacent tendinous structures. The infrequency of injury of the fibular sesamoid of the hallux is attributed by Bizarro to the ease with which this sesamoid escapes into the space between the metatarsal heads following abduction of the toe. The sesamoids to be discussed are those occurring at the base of the big toe joint, at the bases of other metacarpal-phalangeal joints, the accessory scaphoid, the os peroneal, the os trigonum, and the os tibiale internum and externum. Whenever adventitious bones are found in one foot, the other foot should be roentgen-rayed for comparison. These structures have an important medico-legal aspect because some of them are erroneously considered to be fractures. The differentiation from fracture will be simple if it is borne in mind that the edges of a fracture are square, whereas those of a sesamoid bone are round and usually bilaterally symmetrical.

OTHER ACCESSORY BONES OF THE FOOT AND ANKLE

In discussing the accessory bones of the foot, I wish to emphasize that both feet should be examined and great care should be taken in making a diagnosis of fracture because of the medico-legal aspect. Burman and Lapidus* found that while the functional changes due to the inconstant bones and sesamoids are not many, they become important in compensation cases, especially in view of the fact that about 75 per cent of feet present such anomalies (Fig. 184). Inconstant bones seldom disturb the statics of the foot.

These notes are taken from C. Thurston Holland's article in the Robert Jones' Birthday Volume—Oxford Medical Publications, "Accessory bones may be divided into two classes: (1) the sesam-

* The reader who is interested in the functional disturbances caused by the inconstant bones and sesamoids of the foot is referred to an article by Burman and Lapidus which appeared in the Archives of Surgery, 22, 936, June, 1931. A good bibliography is appended.

oid bones, and (2) the true accessory bones The sesamoid bones are those laid down in cartilage and are a regular and typical part of the skeleton The true accessory bones are small ossicles which occasionally are found in certain definite positions and are either separate bones or protrusions from adjacent bones with which they

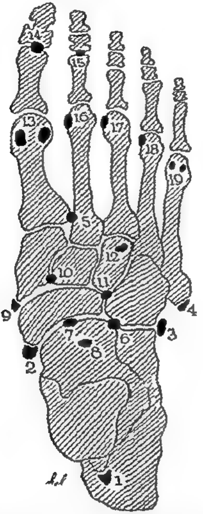


Fig 181 —Diagrammatic ground plan of the inconstant bones and sesamoids of the foot *1* os trigonum *2* accessory scaphoid *3* os peroneum *4*, styloid epiphysis and location of the disputed os vesalianum *5* os intermetatarseum *6* calcaneus secundarius *7* os supranaviculare (seen laterally best) *8* secondary astragalus (seen best on lateral view) *9* os paracuneiforme *10* os intercuneiforme (not described in text since it cannot be seen by roentgen examination and has no practical importance) *11* cuboides secundarius *12* os unci *13* constant sesamoids of the great toe *14* interphalangeal sesamoid of the great toe *15* interphalangeal sesamoid of the second toe *16* *17* *18* and *19*, inconstant sesamoids of the other toes (Redrawn from Burman and Lapidus Arch Surg)

are incorporated These bones are formed from embryonic elements which, instead of disappearing, persist They are always present in certain animals These bones, like others, ossify from centers which, in general, are found from the tenth to twelfth years of life Complete ossification takes place during adolescence They are usually bilateral"

Ossicles and Allied Conditions:
1. Tibiale externum
2. Trigonum, or accessory astragalus
3. Os vesalianum tarsi
4. Secondary os calcis
5. Secondary cuboid
6. Astragalo-scaphoid bone
7. Intermetatarseum
8. Os intercuneiforme
9. Os paracuneiforme
10. Os uncinatum
11. Astragalus secondarius
12. Os subtibiale
13. Os sustentaculum proprium
14. Peroneal process of the os calcis and a separate ossicle
15. Sesamum peronæum
16. Sesamoids of the flexor hallucis brevis
17. Trochlear process of the head of the astragalus
18. Process from the middle of the upper surface of the astragalus
19. Spurs on the phalanges
20. Bipartite scaphoid
21. Bipartite internal cuneiform

The os tibiale externum, or accessory scaphoid, is found on the inner side of the scaphoid and usually in close relationship to the tuberosity of that bone. It is present in from 10 to 12 per cent of all cases. I believe that this bone is very often associated with flat-foot in children, especially flat-foot of the congenital or familial type. In adults, the os tibiale externum may be the source of considerable pain which, if not relieved by non-operative means, may require operation. The operation consists in removal of the accessory bone and, if the tibialis posticus is attached to it, transplantation of that tendon. Sever advises removal of the accessory scaphoid itself and removal of any bony overgrowth. The tendon of the tibialis posticus should be shortened as well. After this procedure, fixation of the foot in an adducted and inverted position by means of a cast for six weeks, followed by a plate for temporary support and by exercises, will give a very good result.

The os trigonum or accessory astragalus is situated behind and below the upper articular surface of the astragalus. It may be a separate bone or attached to the astragalus or the os calcis. (The so-called Shepherd fracture is a free os trigonum.)

The os vesalianum tarsi is found in the space between the tuberosity of the fifth metatarsal and the scaphoid. Holland believes that the so-called bone of Vesalius is in fact the ossification of a large part or all of the fifth metatarsal from the separate center and its persistence in adult life as a separate ossicle.

The bone of Vesalius, or vesalianum pedis, is the proximal and external part of the tuberosity of the fifth metatarsal It is of interest on account of its rarity and the medico-legal importance of its differential diagnosis from fracture of the base of the fifth metatarsal Davis states that it occurs during the period before complete union of the epiphyses has taken place and is not found in the adult The condition is bilateral There are no signs of fracture, such as tenderness, discoloration and swelling The line of cleavage between the vesalianum and the base of the fifth metatarsal is longitudinal, or parallel with the long axis of the fifth metatarsal, and the adjacent surfaces of the two bodies are smooth rather than sharp in outline

The secondary os calcis is situated on the dorsum of the foot and in close relationship to the os calcis, the astragalus, scaphoid and cuboid The secondary cuboid is more closely associated with the scaphoid than with the cuboid When fused to either of these bones, it is more frequently fused to the scaphoid

Geist described a lesion of the surface of the accessory scaphoid bone which he believed was a separate entity and could be differentiated from weak foot Pain and tenderness may be due to irritation of the joint between the scaphoid and the accessory scaphoid, to irritation of the tendon of the tibialis posticus, or to inflammation of the bursa between the tibialis posticus tendon and the accessory scaphoid

The astragalo-scaphoid ossicle is situated on the dorsum of the foot between the upper edge of the astragalus and the scaphoid

The os intermetatarseum is situated between the bases of the first and second metatarsals Occasionally it is present as a distinct bone, but more frequently it is an elongation from the outer distal end of the external cuneiform or fused with the base of the first or second metatarsal

The os intercuneiforme is a small wedge-shaped bone situated upon the dorsum of the foot in front of the scaphoid and separating the proximal parts of the internal and middle cuneiform bones

The os paracuneiforme is situated on the inner side of the foot in the angle between the scaphoid and internal cuneiform

The os uncinatum, which is situated on the plantar surface of the external cuneiform bone, may be separate or merely a hooklike process on the distal end of that bone

The astragalus secundarius is a small oval ossicle lying above and behind the head of the astragalus near the anterior portion of the neck

The os subtibiale is a separate ossification center of the internal malleolus

The os sustentaculum proprium is connected with the sustentaculum tali

Other accessory bones include the peroneal process of the os calcis,

the sesamoid bones, and the os peroneum, usually known as the sesamoid bone in the tendon of the peroneus longus.

Other sesamoids are an interphalangeal sesamoid of the great toe, a sesamoid on the tibial side of the second toe at the metatarsophalangeal joint, one on the fibular side, and one on the tibial side of the metatarsophalangeal joint of the fifth toe, one opposite the distal interphalangeal joint of the second toe, and one on the tibial side of the metatarsal-phalangeal joint of the fourth toe.

Fig 185.—Accessory scaphoid.

Osteochondrosis Necroticans of the Sesamoid Bone of the First Metatarsal.—Kimmelstiel, Kremser, and Richter reported 35 cases of a lesion belonging to the group of insufficiency conditions of the foot which is called "osteochondrosis" or "chondrosis necroticans." It occurs in the sesamoid bone of the great toe. In all, 80 cases have been studied. The predominant changes are necroses and dissolutions of continuity in the cartilage, the osteocartilaginous margins, and the margins between the cartilage and connective tissue. These changes are attributed chiefly to mechanical lesions.

The chief clinical characteristics are pain under the ball of the great toe and tenderness in the region of the affected sesamoid bone. The condition seems to occur more frequently in females than in males. The roentgenograms often show fragmentation, disintegration, vacuolation clearing, thickenings, and crumbling. The condition must be differentiated from gout, fractures, and postural defects. As a rule it runs quite a chronic course. In general, the treatment should be conservative. If conservative treatment is unsuccessful, the sesamoid bone should be removed

Lapidus examined, in the New York Museum of Natural History, 320 extremities of various mammals—56 fossils, 192 primates, and 72 other mammals—with special reference to the sesamoids. Two sesa-

moids were found beneath each metacarpal or metatarsal head in almost all adult specimens including 56 extremities of fossil animals

Lapidus called attention to the existence of disabling symptoms caused by various lesions of the inconstant foot sesamoids, the presence of which is frequently ignored He found a case of fracture of the left second tibial sesamoid and described the pathological findings of the sesamoid removed at operation Three cases of congenital bipartite inconstant sesamoids of the foot are also given A case of calcareous tendinitis around the tibial sesamoid of the second toe is reported

CHAPTER XV

AFFECTIONS OF MUSCLES, TENDONS, FASCIÆ, AND BURSÆ OF THE FOOT AND ANKLE

MUSCLES OF THE FOOT

The muscles of the foot are the interrossei, lumbricales, abductor hallucis, adductor hallucis, peroneus tertius, extensor digitorum brevis, quadratus plantæ, flexor digitorum brevis, abductor minimi digiti, and flexor hallucis brevis.

All other motor functions of the foot and ankle are performed by muscles which arise in the leg but whose tendons are inserted in the foot.

Hoke emphasizes the importance of three muscles and tendons, the anterior tibial, the posterior tibial, and the long flexor of the big toe. (Fig. 11.) He says that these three tendons must grasp and grip the ground if the patient is to have a good step.

The most important muscle conditions occurring in the feet and legs are myositis and myofascitis. These are caused by overactivity, imbalance, infection and trauma: the factors responsible also for arthritis.

Spasms—Cramps.—Muscle spasm occurs in the arch of the foot and the big toe, but especially in the calf. It is probably due to overactivity, imbalance, and trauma.

Cramps of muscles are due to an excess of lactic acid in the muscle. The treatment of this condition is discussed fully in Chapter XXXIV. Some of the measures recommended are "bicycle pedalling," massage, and standing on a cold surface. One of the best things is to get out of bed before the spasm reaches its maximal contraction. In some severe cases adhesive strapping, splinting, and physical therapy are necessary. Quinine sulfate (gr. 3, three times a day) is said to be a very effective preventive.

Gottlieb described the case of a driver who jumped off his truck, landing on the tips of the outer three toes with his foot in supination. He suddenly felt sharp pain in the antero-lateral surface of the right leg, caused by a tear in the tibialis anticus muscle.

Muscle Dystrophies.—The foot of the dystrophic child is always weak, whether the condition is a pseudohypertrophic muscular dystrophy, amyotonia congenita or any other type of dystrophy involving bone or muscle. The foot of the child with amyotonia is called the

"pad foot" The child with pseudohypertrophic muscular dystrophy usually develops talipes equinus Both vitamins B_6 and E have been recommended for muscle dystrophies

Myotonia congenita is characterized by a hypertonic condition of the muscles, which manifests itself by stiffness and delayed relaxation Movement may appear normal until the patient changes the direction in which he is walking Quinine has been found to be of value in this condition

The most important neoplasms of muscle include myoma, rhabdomyoma, leiomyoma, sarcoma, fibrosarcoma, lipoma and angioma

TENDON LESIONS

The four most important tendons in the foot are the anterior tibial, the posterior tibial, *the flexor hallucis longus, and the tendo Achillis*

Anatomy —The microscopic and macroscopic anatomy of the tendons and their attachments to muscle and to bones will not be given in detail (The reader is referred to such works as Biesalski and Mayer, Steindler, and others, and to my chapter on Poliomyelitis) Tendons are made up of dense fibrous connective tissue which is not very elastic

Physiology —Tendons are the links between the muscles and the skeletal framework which the muscles move It is a physiological law *of elastic tissue that if stretched it loses power, if allowed to shorten* it gains power Tendons are among the most adaptable tissues of the body They unite with practically any tissue, including each other They are at the beck and call of muscles and will act unless bound down with adhesions A tendon in a tendon sheath is like an umbrella in an umbrella cover, there must be free play or no action will occur If there is any adhesive contact between the tendon and its sheath there will be limitation of the activity of the tendon It is comparable to pouring glue down the outside of the umbrella and then putting the cover on Attempts to pull it off will result in failure or tearing of fabric

By *means of a tendon*, the force of a powerful muscle is concentrated on a small area thereby enhancing the effect of leverage When muscles are inserted directly into bone without the intervention of tendon, the mechanism gains power at the expense of speed and accurately focused force

Etiology —Tendon disturbances may be due to congenital anomalies, traumas, infections and new growths The most important are the traumatic affections Tendon tissue itself is not often susceptible to infection The tendon sheath and insertion contacts are susceptible Conditions which affect the tendon are tendinitis, or tenosynovitis or tenovaginitis, sprain, strain or rupture, disease such as tuberculosis

or syphilis, displacement of the tendon and avulsion from the muscle or from its bony attachment.

Burman and Milgram place traumatic, pyogenic, gonorrheal, syphilitic, and tuberculous tenosynovitis in one group. A neuropathic tenosynovitis has been described. Aspiration will clinch the diagnosis in many cases in which the history, physical examination, and roentgen-ray findings are inconclusive. "Rheumatic" tenosynovitis may occur in conjunction with arthritis. Baracz reported on rheumatic tendinitis of the Achilles tendon. The swelling surrounds the tendons and extends from the heel insertion to the origin of the tendon. Single nodules in the tendon are often palpable and are thought to be depositions of urates. Tendon sheaths are akin to joints and bursa. When inflamed they may simulate a tumor due to their papillomatous outgrowths. Chronic inflammatory tumors of tendons have been described. The ganglion is a degenerative cyst of the tendon sheath wall.

Symptoms and Treatment.—Symptoms of tendon lesions are pain, tenderness, swelling, crepitus and limitation of motion. Treatment includes immobilization, physical therapy and operation. The latter includes manipulation or stretching, tenotomy, tendon lengthening, tendon plastic, tenorrhaphy, tendon transplantation and transposition or grafting. It is improbable that tendons stretch rapidly. It is more likely that the tendon is avulsed from the muscle, or partially or completely torn from the bone. As a rule, normal tendon does not rupture, but breaks occur at the points of origin or insertion, at the musculotendinous junction, or within the muscle belly.

Occupational Tenosynovitis.—There is a group of lesic[illegible] occupational tenosynovitis. There may be an eleme[illegible] myositis, which is analogous to such conditions as rider' shoulder, fencer's bone and dancer's bone. Other anal[illegible] are interstitial calcinosis, arthritis, myositis, synoviti[illegible] ficans, myositis ossificans para-arthritica and occupa[illegible] vitis due to repeated injuries. These conditions [illegible] infection and trauma. Trauma may be [illegible] minimal strains or sprains.

If there is no free play of a tendon in [illegible] crepitus may be noted when the tendon [illegible] tenosynovitis. Treatment implies re[illegible] those activities which cause crepitus a[illegible] of a plaster-of-Paris cast for a few days [illegible] splint should be tried. The splint sho[illegible] radiant heat and inductotherm. The co[illegible] upon the patient's response.

INJURIES TO TENDONS

Many cases of partial and complete ruptures of muscles and tendons remain undiagnosed for weeks, months, or years, or are incorrectly diagnosed The treatment is surgical

Mason offers the following classification of subcutaneous tendon rupture

A Direct trauma—the tendon is caught between the bone and the traumatizing agent

B Indirect trauma—the forcefully contracting tendon is subjected to forceful passive force in the opposite direction

C Spontaneous rupture —1 Post-traumatic—aseptic necrosis or degeneration of tendon due to single severe or often repeated minor trauma 2 Disease of tendon, *e g*, tuberculosis, gonorrhea, syphilis or gout *

Platt divides tendon ruptures into two main groups (1) The common rupture, produced by the sudden powerful overstretching of a muscle already in a state of contraction A well-known example is rupture of the tendo Achillis (2) The spontaneous rupture seen in certain tendons which occupy a bony groove where the rupture is determined by a preexisting adhesion of the tendon, which gradually becomes attenuated and ultimately snaps in response to a comparatively trivial violence

Tendon ruptures may also be classified according to the site of the tear, which may take place (*a*) at the musculotendinous junction, (*b*) in the tendon itself, or (*c*) at the point of insertion Tears in the neighborhood of the musculotendinous junction are usually incomplete and are similar to partial tears of the muscle belly

Exposed tendons or joints especially following crushing injuries, do poorly They are likely to become infected and later slough Antiseptic dressings may destroy the linings of joint cavities, tendon sheaths, and tendons Dorrance and Bransfield use pedicle flaps immediately to cover exposed tendons or joints

Steindler improved his results by employing physiological tendon transplantations He emphasizes proper regard for the gliding apparatus of the tendon, according to the investigations and technic of Biesalski and Mayer, and the integrity of the mesotenon in preserving the nutrition and vitality of the transplanted tendon (See Chapter on Poliomyelitis)

Rules for Tendon Operation Include (1) Respect the blood supply, (2) preserve the gliding mechanism of the tendon apparatus Although

* The reader who is interested in attrition lesions is referred to the articles of A W Meyer

or syphilis, displacement of the tendon and avulsion from the muscle or from its bony attachment.

Burman and Milgram place traumatic, pyogenic, gonorrheal, syphilitic, and tuberculous tenosynovitis in one group. A neuropathic tenosynovitis has been described. Aspiration will clinch the diagnosis in many cases in which the history, physical examination, and roentgenray findings are inconclusive. "Rheumatic" tenosynovitis may occur in conjunction with arthritis. Baracz reported on rheumatic tendinitis of the Achilles tendon. The swelling surrounds the tendons and extends from the heel insertion to the origin of the tendon. Single nodules in the tendon are often palpable and are thought to be depositions of urates. Tendon sheaths are akin to joints and bursa. When inflamed they may simulate a tumor due to their papillomatous outgrowths. Chronic inflammatory tumors of tendons have been described. The ganglion is a degenerative cyst of the tendon sheath wall.

Symptoms and Treatment.—Symptoms of tendon lesions are pain, tenderness, swelling, crepitus and limitation of motion. Treatment includes immobilization, physical therapy and operation. The latter includes manipulation or stretching, tenotomy, tendon lengthening, tendon plastic, tenorrhaphy, tendon transplantation and transposition or grafting. It is improbable that tendons stretch rapidly. It is more likely that the tendon is avulsed from the muscle, or partially or completely torn from the bone. As a rule, normal tendon does not rupture, but breaks occur at the points of origin or insertion, at the musculotendinous junction, or within the muscle belly.

Occupational Tenosynovitis.—There is a group of lesions called occupational tenosynovitis. There may be an element of multiple myositis, which is analogous to such conditions as rider's knee, soldier's shoulder, fencer's bone and dancer's bone. Other analogous conditions are interstitial calcinosis, arthritis, myositis, synovitis, myositis ossificans, myositis ossificans para-arthritica and occupational tenosynovitis due to repeated injuries. These conditions may be caused by infection and trauma. Trauma may be one severe blow or multiple minimal strains or sprains.

If there is no free play of a tendon in its sheath, palpable and audible crepitus may be noted when the tendon is active. There may be a dry tenosynovitis. Treatment implies rest. The patient should avoid those activities which cause crepitus and discomfort. The application of a plaster-of-Paris cast for a few days is advised. Later a removable splint should be tried. The splint should be removed twice daily for radiant heat and inductotherm. The continued use of massage depends upon the patient's response.

INJURIES TO TENDONS

Many cases of partial and complete ruptures of muscles and tendons remain undiagnosed for weeks, months, or years, or are incorrectly diagnosed The treatment is surgical

Mason offers the following classification of subcutaneous tendon rupture

A Direct trauma—the tendon is caught between the bone and the traumatizing agent

B Indirect trauma—the forcefully contracting tendon is subjected to forceful passive force in the opposite direction

C Spontaneous rupture —1 Post-traumatic—aseptic necrosis or degeneration of tendon due to single severe or often repeated minor trauma 2 Disease of tendon, *e g*, tuberculosis, gonorrhea, syphilis or gout *

Platt divides tendon ruptures into two main groups (1) The common rupture, produced by the sudden powerful overstretching of a muscle already in a state of contraction A well-known example is rupture of the tendo Achillis (2) The spontaneous rupture seen in certain tendons which occupy a bony groove where the rupture is determined by a preexisting adhesion of the tendon, which gradually becomes attenuated and ultimately snaps in response to a comparatively trivial violence

Tendon ruptures may also be classified according to the site of the tear, which may take place (*a*) at the musculotendinous junction, (*b*) in the tendon itself, or (*c*) at the point of insertion Tears in the neighborhood of the musculotendinous junction are usually incomplete and are similar to partial tears of the muscle belly

Exposed tendons or joints, especially following crushing injuries, do poorly They are likely to become infected and later slough Antiseptic dressings may destroy the linings of joint cavities, tendon sheaths, and tendons Dorrance and Bransfield use pedicle flaps immediately to cover exposed tendons or joints

Steindler improved his results by employing physiological tendon transplantations He emphasizes proper regard for the gliding apparatus of the tendon, according to the investigations and technic of Biesalski and Mayer, and the integrity of the mesotenon in preserving the nutrition and vitality of the transplanted tendon (See Chapter on Poliomyelitis)

Rules for Tendon Operation Include (1) Respect the blood supply, (2) preserve the gliding mechanism of the tendon apparatus Although

* The reader who is interested in attrition lesions is referred to the articles of A W Meyer

tendon is composed of one of the lowest forms of tissue, it is easily infected and will sequestrate.

Tendon Suture.—Koch advises that primary suture of tendon (using white silk) should be carried out only when the following situations obtain:

1. If the wound is clean
2. If seen within two hours of the accident
3. If proper facilities are available
4. If aseptic and antiseptic precautions are taken in the operating room
5. If trained assistants are available

TENDON LENGTHENING

(For a review of methods see the Chapter on Poliomyelitis)

I devised a method of tendon lengthening that can be used in the larger tendons. It is called the "four-three-two" method. Four longitudinal incisions are made in the tendon; then three transverse incisions are made above, alternating; and two transverse incisions below. This makes four strips of the tendons which glide on each other and can be anchored with catgut sutures in any desired location.

TRANSPLANTATION OF FIBROUS TISSUE, FASCIA AND TENDON

In the transplantation of fascia, aponeurosis, and tendon for the repair of anatomical defects, Gallie and LeMesurier found these tissues heal, to whatever structures they make contact, by scar—the strength of which depends on the degree to which the surfaces are denuded and scarified and on the area of these apposing surfaces. They grouped their orthopædic cases into: injuries to tendons; injuries to ligaments; certain ununited fractures; and paralytic deformities.

Mason and Shearon found that in tendon suture any sheath tissues present should be as carefully approximated as the tendon because they unite early and function while the tendon is proliferating. Accurate end-to-end apposition of tendon stumps is conducive to healing. In sutured tendons, movement may be started cautiously by the fifth or sixth day, but no force should be exerted before the third week. Defects in tendons should be filled with a tendon graft plus its sheath tissues, as the tendon graft forms true tendon which will not stretch.

Joints must be mobilized before tendons are repaired or no motion will result. One cannot expect a newly repaired tendon to move a stiff joint; nor should he repair a bone, and at the same time a tendon or joint. The former demands postoperative immobilization and the latter mobilization.

MUSCULAR RELAXATION PRODUCED BY NOVOCAIN

McNealy and Lichtenstein found that novocain injected intramuscularly abolishes the influence of the nervous system on the muscle injected. Repeated injections with novocain of a muscle, the tendon of which has been severed, is sufficient to induce continuous muscular relaxation by eliminating the primary hypertonic contracture. The decrease of tendon retraction permits an earlier healing by lessening the amount of fibrous tissue which is necessary to fill in the gap.

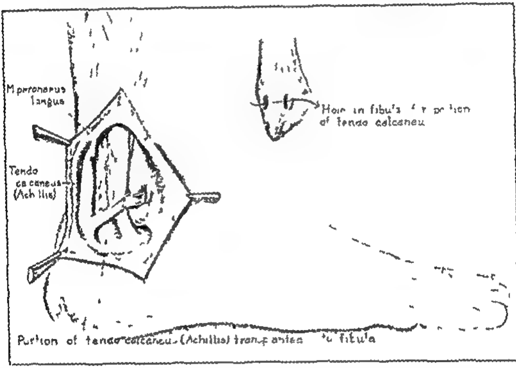


FIG. 160.—Ellis Jones' operation for the cure of dislocation of peroneal tendons. The operation prevents redislocation by furnishing a capable substitute for a retinaculum and fulfills all the physiological, anatomical and mechanical requirements. The peroneus longus tendons are exposed by a straight incision 2 inches in length, extending downward directly behind the external malleolus. The tendo Achillis is exposed and a tendon slip 2½ inches in length and approximately ¼ inch in width is freed from above downward and left attached at its calcaneal insertion. The peroneal tendons in their sheath are firmly retracted. A hole is drilled transversely through the fibula 1 inch above the tip of the malleolus and the tendon slip is passed from behind forward through the drill hole, looped posteriorly and sutured with twenty-day chromic suture both to the periosteum of the fibula and to the tendon slip itself while the foot is held strongly dorsiflexed in full supination. The peroneal sheath is not opened. (Jones, courtesy of Jour. Bone and Joint Surg.)

Tennis Leg.—"Tennis leg" is usually due to rupture or a tear of the plantaris, but some authors include tears of the calf muscles and the Achilles tendon. The history of these cases is typical: it seems that at the time the player springs or attempts to spring, or suddenly turns the body with legs held straight, he produces a spiral twist of the muscles. Tennis players feel a surprising, sudden pain in the calf as though

hit by a stone and fall to the ground. They think that the fall ruptured the muscle, but the rupture was primary. An early diagnosis should be made if possible. Joint symptoms, particularly in the knee, should not mislead one in the diagnosis. Early surgical repair in an extensive or complete tear saves much time and is followed by a better result.

The most important *displacement* of foot tendons is that of the peroneals, which may slip over the external malleolus and the flexor hallucis brevis with its sesamoid. Jones calls attention to the fact that in the former displacement, the superior retinaculum is invariably ruptured, leaving no structure capable of retaining the tendon in its normal position. In his method of tenoplasty, reduction of the dislocated tendon is maintained by a tendon slip fashioned from the tendo Achillis at its calcaneal insertion and implanted into the external malleolus. (Fig. 186.) Jones has found that the transplanted tendon acts as a thoroughly adequate substitute for the ruptured retinaculum.

Contractures may occur in any of the tendons of the foot and ankle but are most common in the Achilles tendon, the extensors of the toes, the extensor hallucis longus, the tibials, and the peroneals.

Contracture of the Achilles tendon may be congenital or due to the wearing of high-heeled shoes.

Contraction occurs chiefly in the toe flexors, extensors, and Achilles tendon. Contraction of extensor tendons can be relieved by tenoplasty, forcible correction, and retention in the over-corrected position for a long time. Volkmann's ischemic syndrome has been reported in the lower extremity.

ACHILLES TENDON REGION*

The Achilles tendon area is often an excellent indicator of the general health. I never fail to observe this area to see whether the Achilles tendon stands out prominently and has depressions on each side of it. In cases of water retention, cardiac or kidney lesions, the depressions are filled out and the normal anatomical landmarks do not show.

Achillodynia.—Achillodynia or pain in the region of the Achilles tendon, may be caused by tenosynovitis, contraction of the tendon, calcaneal spurs and other exostoses, apophysitis, tuberculosis and osteomyelitis of the os calcis, ossifying tendinitis, and bursitis. As a rule it can be relieved by removing the counter of the shoe and increasing the

* The mother of Achilles, Thetis, like all good mothers, wanted her boy to become a superman, and so she saw to it that he learned not only the arts of war and eloquence, but also music and medicine. And after seeing to it that her offspring would become matchlessly strong of body and brilliant of mind, it was only natural that she should dip Achilles into the River Styx so that he might become safe from all harm—invulnerable to all evil. Good Mother Thetis overlooked just one thing in the dipping—Achilles' heel—and so her precautions for invulnerability went for naught. (Elmer H. Bobst.) Remark.—If a horse's achilles were cut he was shot.

height of the heel Achillodynia is most frequent in the winter when pressure is combined with chilling of the tissues

Achillobursitis will be described under *Bursæ*

Tenosynovitis —Tenosynovitis of the Achilles tendon is characterized by pain, limp, disability, and palpable crepitus on movement It is caused by a severe sudden trauma, repeated slight injuries, or a strain such as is incurred in walking up a steep hill It may result also from infection Treatment *consists of rest with the limb elevated* and the application of hot moist dressings When the patient is allowed on his feet the ankle should be strapped and the heel of the shoe elevated to relax the tendon

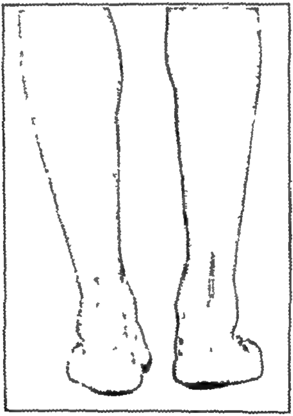


Fig 187 —Tendinitis of right Achilles tendon Note thickening and widening

Calcification and Ossification —Calcification in or of the Achilles tendon may follow injuries, such as knife wounds or rarely after tenotomy

Ossifying tendinitis, tendinitis ossificans or peritendinitis calcarea is a condition in which the connective-tissue cells undergo a *metamorphosis* and form bone (Fig 188)

Mazzini, Silveyra and Monzo report two cases, one of them bilateral, in men of forty-six and forty-three years respectively Trauma was present in both cases, in the first a subcutaneous tenotomy for club-

feet forty years previously, in the second, an electric burn of the foot and leg. The first patient had intermittent claudication although the clinical examination revealed no circulatory disturbance. A trochlear process of the astragalus in one patient and a peroneal bone in the other were seen in the roentgenograms. These authors summarize the 15 reported cases of ossifications in the tendo achilles.

Fig. 188.—Ossifying Achilles tendinitis (peritendinitis calcarea) (a rare lesion) (Courtesy of Dr. S. Sideman.)

Special Exercises for "Stretching" the Achilles Tendon: 1. Simply walk on the heels across the room five times.

2. From the standing position with the feet parallel, squat down to the position of sitting on the heels, maintaining the heels and toes on the ground. This is done in two counts, five times.

3. Stand facing the wall with the toes 28 inches from it. Place the toes together and the heels as far apart as possible. Place the hands against the wall and then, maintaining the heels on the floor, allow the entire rigid body to move forward as far as possible by bending the elbows. Remain in this position a few seconds before returning to the starting position. This is done in two counts, about ten times.

4. An apparatus consisting of two handles fastened to the wall and a heavy wood block $3\frac{1}{2}$ inches high, 12 inches wide, and 7 inches deep, which is fastened to the floor is used. The position to be assumed is to face the wall, stand with both forefeet on the block, and hold onto the handles. On the count of one, allow the heels to touch the

floor, maintaining the body parallel with the wall On the count of two, return to the starting position (Fig 189) The exercise is carried out from ten to twenty times, this number being attained gradually

5 Stand with the forefeet on a stair, facing upward Holding the balustrade, allow the heels to drop down Then return to the starting position

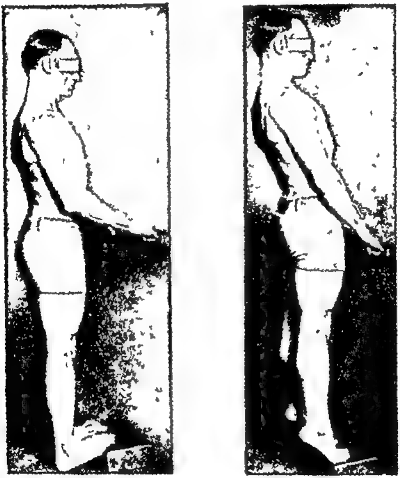


Fig 189 —Exercise for stretching Achilles tendon Excellent posture while performing heel tendon stretching exercise (Lewin courtesy of Jour Am Med Assn)

Rupture of the Tendo Achillis—Rupture of the tendo Achillis usually occurs in middle life John Hunter was a victim of this accident The three chief ways in which this tendon is divided are severance by a cutting instrument or a projectile, a sudden contraction of the triceps suræ or external trauma without division of the soft parts Many partial or incomplete ruptures of the Achilles tendon are referred to as rupture of the plantaris tendon Incomplete tear in the lower part of the Achilles tendon may be converted into a complete rupture by a second injury The tendon may be ruptured while boxing (Rupture of the plantaris tendon is a common injury) Achilles tendons

have been ruptured by simple muscle violence such as occur in tennis, handball, and squash rackets. It is most apt to occur when the foot is in extreme dorsiflexion and the Achilles tendon taut. Severe pain is experienced in the calf, and the patient usually falls to the ground. One patient whom I saw was playing squash rackets when the tendon was ruptured. At operation its torn ends were separated and a large hematoma was present. It looked very much like the condition found in an open reduction of a fresh fracture. Complete rupture of the Achilles tendon usually occurs at its narrowest part, which is about $1\frac{1}{2}$ inches above its insertion. There is a severe, sudden, sharp attack of pain as if a direct blow were received over the tendon. There are immediate disability, swelling and tenderness. Plantar flexion is impossible. The signs are: (1) a gap into which one's finger can be introduced and which is increased by dorsiflexion of the foot; (2) high retraction of the calf belly; (3) abnormal range of passive dorsiflexion as compared with the normal side (this is absent in partial rupture); (4) the loss of true gastrocnemius and soleus action in plantar flexion, a movement which may still be carried out with a fair degree of force by a combination of the peroneus longus, tibialis posticus and the long flexors of the toes. The break in continuity in the tendon may be demonstrated in a lateral roentgenogram taken with short exposure to bring out soft tissue shadows.

The rupture may be represented by a clean transverse section or the tendon fibers may break at different levels leaving ragged, skeinlike ends. The sheath may be uninjured. More frequently there is a gap on the posterior aspect. Immediately following rupture the proximal end retracts, due to the pull of the powerful calf muscles. The interior of the sheath rapidly fills with blood and the walls of the sheath become edematous. The plantaris tendon usually remains intact.

Complete rupture should be repaired by operation as soon as possible. The clot should be removed and traction applied to the proximal end of the divided tendon while the ankle is in plantar flexion, and the knee flexed to relax the calf group so that the ends can be approximated without undue tension. Transfixation is accomplished by sutures of kangaroo tendon or heavy chromic catgut inserted transversely well above and below the line of rupture. This should be reinforced by sutures of catgut of smaller caliber. The site of rupture may be reinforced by living suture made from fascia lata. The tendon sheath should be carefully restored wherever practicable. The leg should be put in plaster-of-Paris with the foot in full plantar flexion and the knee in flexion. A walking iron is added. Three weeks later the foot is brought gently to the right-angle position and another plaster applied, and the patient is allowed to increase his range of walking. Six weeks from the time of operation, the plaster is removed and walking is

allowed in a shoe with an elevated heel. Massage is added for stimulation of the calf muscles, graduated exercises follow and reeducation in a normal heel and toe gait is prescribed.

In late repair, Platt emphasizes the importance of reinforcement of the suture line by strong fascial strips. The plantaris tendon may be used. In exceptional cases where the gap cannot be closed by direct suture, either the turning down of a flap or the insertion of a free tendon graft may be performed. If a graft is used, it is wise to strengthen the power of plantar flexion by transplanting the peroneus longus and the tibialis posticus tendons to the os calcis at the site of the Achilles insertion.

The split tendon makes an ideal suture for the purpose of sewing together the freshened ends of the tendo Achillis if these can be overlapped. It may be used to bridge a gap when the ends of the severed tendon cannot be approximated.

Late repair of a ruptured tendo Achillis at its attachment to the os calcis was accomplished by Gallie and LeMesurier by using half of the split Achilles tendon as a free transplant, passed through a hole in the os calcis and anchored there with catgut, the two halves of the tendon *to be sewn together with a 3-inch overlap. The plantaris tendon may* be used as a suture to reinforce the repair.

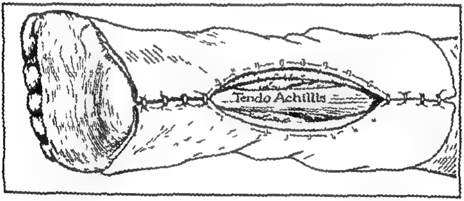


FIG. 100.—The application of Michel clips to towels and skin to exclude the latter as a source of infection. (Lewin, courtesy of Jour. Bone and Joint Surg.)

"Muscle-bound Foot."—*This is a term used to describe a condition* in which movement is limited because of shortening of the soft tissues, especially the Achilles tendon. Hibbs recommends a tendon plastic operation. Haggard emphasized the importance of contracted calf muscles in this condition.

The tendon should be lengthened by gradual lowering of the height of the heel and special exercises. If these measures are unsuccessful, tenoplasty should be considered.

Hibbs says that a certain amount of relief is obtained from exercises

and massage, while properly fitting plates often relieve foot strain and hold the foot in better relation to the leg. High-heeled shoes are more comfortable, and walking with a slightly bent knee is less fatiguing. It is impossible to give permanent relief until the limitation to dorsal flexion is removed and the normal muscle balance is restored, which should be done before changes in the foot have taken place and the nervous system has become affected.

Lengthening of the Achilles tendon removes the limitation to dorsal flexion and inhibits the function of the calf for from two to three months in children and from four to six months in adults, giving time for proper development of the opposing muscles and the intrinsic muscles of the foot and for the complete restoration of normal muscle balance.

In the operations for **Lengthening the Achilles Tendon** the skin incision is made along the outer border of the tendon, the sheath is split, and the tendon is lengthened, the amount of lengthening depending upon the degree of ankle flexion desired. The sheath is sutured. Plaster is applied while the foot is held at a right angle to the leg.

At the end of three weeks the patient is allowed to walk, and resistive exercises for the anterior muscle group are begun. In cases of adults, ankle braces with a reverse catch should be applied and worn for three or four weeks in order to give a sense of security and to prevent extra strain upon the calf. At the end of twelve weeks in the cases of children, and from four to six months in those of adults, the result is usually perfect.

I prefer Hoke's step-operation technic, which does not sever the continuity of the tendon. (Fig. 192.) The explanation of the difficulty encountered in lengthening the heel cord by simple subcutaneous tenotomies lies, according to J. Warren White, in the fact that there is approximately a 90 degree twist of the structure on its own axis within the surgical field and that when even two-thirds of the medial fibers have been severed at one level and two-thirds of the lateral fibers at another level, enough fibers miss being cut to cause the tendon to "hang." An ordinary twisted Manila rope would behave in the same way if cut partially at different levels and cognizance were not taken of the twist to make appropriate cuts.

When this abnormality in the internal structure of the Achilles tendon is appreciated and the transverse partial tenotomies are made with it in mind, no difficulty is experienced in lengthening a tendon previously not operated on. If the anterior two-thirds of the heel cord is severed a convenient distance above its insertion into the calcaneal tuberosity, and the medial two-thirds is severed 2 or 3 inches above this point in an adult, no difficulty is experienced in elongating the tendon by applying a moderate dorsiflexion force to the forefoot, in an uncompli-

cated equinus deformity. The exact technic employed calls for starting the proximal transverse tenotomy on the medial side of the tendon, after the anterior two-thirds have been cut about 2 inches distally, continuing with it laterally until the tendon sections are felt to slide apart while the previously mentioned moderate dorsiflexion force is being applied to the forefoot.

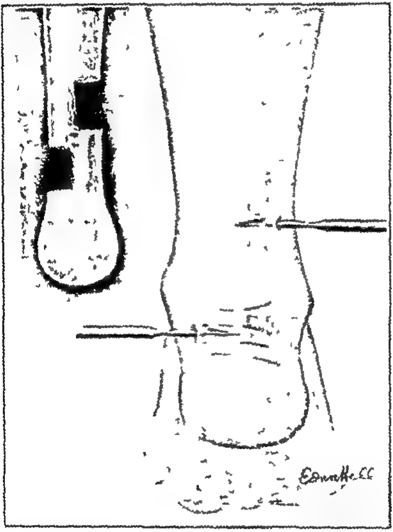


FIG. 191.—Illustrating the double subcutaneous tenotomy of the tendo Achillis. (Gill; courtesy of Surg. Clin. North America, W. B. Saunders Company.)

Regardless of the correctness of the explanation, the subcutaneous tenotomy, using only the two specially directed partial transverse cuts permits the two tendon sections to slide apart with sufficient ease to simplify the lengthening of the Achilles tendon and is recommended for routine use. I often incorporate a walking iron in the cast and permit weight-bearing within a few days.

Some surgeons prefer to release the gastrocnemius aponeurosis

TUMORS OF THE TENDON SHEATHS

Tumors of the tendon sheaths are closely related to tumors of joints and bursæ. The basic cell of all these tumors, according to Morton, is the synovial cell, which is a modified mesenchymal cell with multipotential qualities. It may revert in one direction to the fibroblast or may go over into cartilage and bone in the other.

Among neoplasms of the tendon, benign osteochondromata, ganglions, and giant cell tumors or xanthomata predominate. These tumors bear a relationship to precartilaginous tissue. Fibromata and lipomata also may occur. Chondrosarcoma at or near the insertion of tendons into bones and fibrosarcoma of the tendon sheaths are two rare forms of malignancy found in these structures.

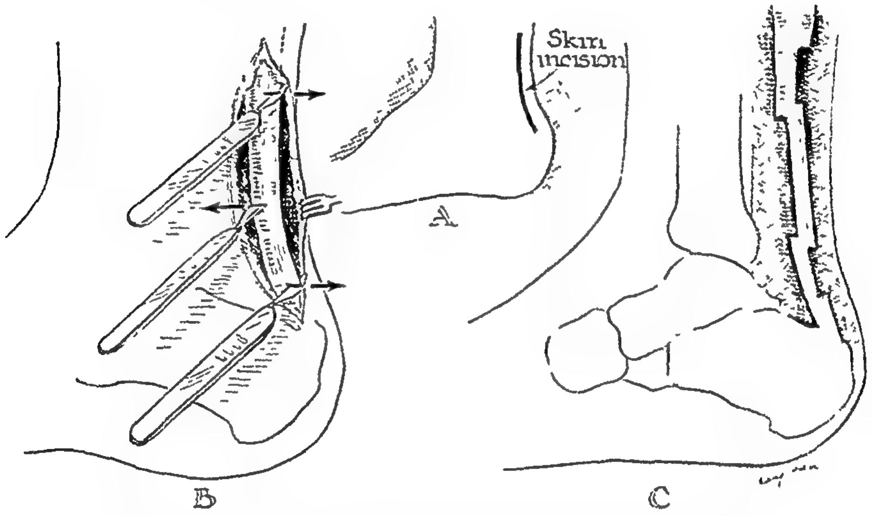


FIG. 192.—Hoke technic for lengthening Achilles tendon.

Primary tumors of tendons are very rare, the commonest being sarcomas. Primary tumors of tendon sheaths are more common, especially the giant-myelomata or granulomata and hemangiomata. Tumors of tendon sheaths arise from the cells of the synovial membrane of the sheath.

Tendon sheath cells are modified connective tissue cells similar to those lining the joints and bursæ. The tumor cells may be spindle or spheroidal and may merge from one into the other and form spaces which are comparable to the synovial cavity. King favors the term tenosynovioma. Synoviomas may be innocent or malignant. The former may be fibrous, cartilaginous, fatty, vascular, osseous or mixed. These may be complicated by the presence of giant cells or foam cells.

Tumors of tendon sheaths are insidious in onset. There is seldom pain. The most constant observation is swelling which may reach the size of a small orange. The lesion may be localized or extend along the

tendon. It usually grows very slowly. Trauma is an important feature, according to King, particularly in the cases which show giant cells and "foam" cells. A large number of the growths occur on the flexor tendons of the hand. When the skin becomes involved it becomes bluish in color and finally breaks down. Metastases have been reported in the liver and lungs. Tumors of tendon sheaths are reddish yellow or gray in color. They are attached to the sheath and may involve a considerable portion of its length on one aspect or may completely surround it. Calcareous material, chondroma, fibroma, fatty tumors, angioma, and lymphangio-endothelioma have been reported. Some tumors resemble chronic tenosynovitis.

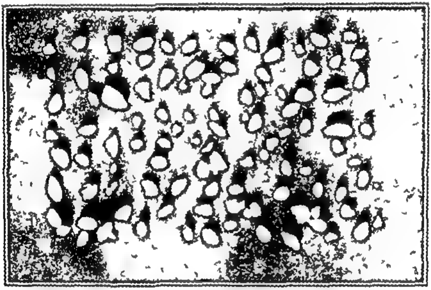


Fig. 193.—Rice bodies removed from a tendon sheath. (Courtesy of Dr. S. Sideman.)

The differential diagnosis between tumors of tendon sheaths and inflammatory diseases, especially the granular type of tuberculous tenovaginitis, is difficult.

Xanthoma is a slow growing tumor that arises chiefly in the tendon sheath and upon erosions of the hands and feet. If it grows rapidly one suspects malignant degeneration. According to Ewing, it seldom reaches the size of a hen's egg. It is well encapsulated, firm, opaque and yellowish, and lobulated. It is readily shelled out at operation. It never produces metastasis and rarely recurs after excision. In a report of cases of multiple xanthoma of the tendons, McWhorter and Weeks divided them into the diabetic, multiplex, and the palpebral types. They concluded that all forms of xanthoma are the result of a systemic disease in which hypercholesterolemia is an essential feature. The pathologic changes represent an irritative connective tissue reaction due to the deposit of cholesterin.

FASCIÆ

Fascia is composed of pure fibrous tissue.

The causes of fascial disturbances are infection, injury, rupture and puncture. The pathological changes in fasciæ are hypertrophy, tumor, rupture, and fibrositis.

The symptoms of fascial lesions are pain, limitation of movement, and deformity. The treatment includes rest, physical therapy, and surgery.

Fascial spaces in the foot are important from the standpoint of infections which follow the fascial planes as their routes of spread. These infections naturally are not so important as in the hand but may be very serious.

Grodinsky made a careful study of these conditions. (Figs. 114 and 115.) The special locations where fasciæ are important in the foot are in the plantar surfaces and between the metatarsal bones.

The Plantar Fascia.—The plantar fascia extends from the os calcis to the four outer toes. It is subject to particular strain and sprain in jumping. In cases of flat-foot it is usually under considerable tension. It may become contracted as the result of fascitis due to infection or mechanical causes.

A condition similar to Dupuytren's contracture of the palmar fascia has been reported in the foot. This is evidently due to contracture of the plantar fascia as seen in pes cavus.

Operations on the fascia are performed according to Steindler's technic (Fig. 144) or by subcutaneous fasciotomy. I make a small incision along the inner border of the foot, midway between heel and toes, insert a blunt scissors, manipulate the scissors until the fascia is between the blades, and then cut.

BURSÆ OF THE FOOT AND ANKLE

A bursa is a synovia-secreting sac situated near the attachment of a muscle which exerts considerable pull. It is nature's defense against irritation, but unfortunately, if the irritation persists, the inflamed bursa is more painful than the original situation.

The function of the bursæ is to reduce friction between the skin and prominent underlying structures; between a tendon and a hard underlying structure and between a tendon or group of tendons and a bony structure. Subtendinous bursæ are often found near joints where there is continuity between the bursa and the synovial membrane which lines the joint; this is especially true at the knee and elbow.

Bursæ occur around the os calcis, internal and external malleoli, the dorsum of the forefoot, under the metatarsal arch, and over the prominence of a hallux valgus. Bursæ are frequently associated with foot strain, dorsal contractures of the toes, paralysis or static deformities of

the foot, spurs on the os calcis, and epiphysitis Ill fitting shoes are the most common causes

To the bursæ under the os calcis, at the lower extremity of the tendo Achillis and over the metatarso-phalangeal joint of the great toe, Spalteholz adds those overlying the capsules of the metatarso-phalangeal joints of all of the toes Hertzler called attention to a constant bursa between the flexor tendons and the head of the abductor hallucis,

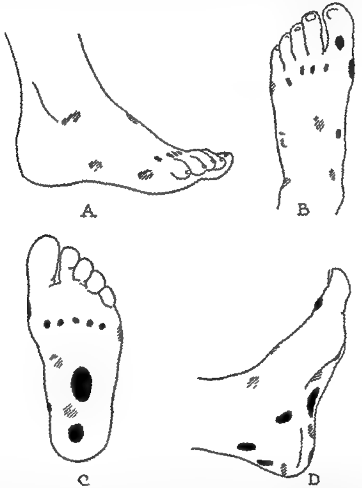


FIG 104 —*A*, Common sites for adventitious bursæ on the outer side of the foot *B* Bursæ of the dorsum of foot Solid lines indicate constant bursæ Broken lines show location of adventitious sacs frequently found *C* Showing locations of the subcalcaneal bursa muscular and metatarsal bursæ and of those found in the superficial fascia of the sole *D* Medial view of foot showing location of permanent and adventitious bursæ (Redrawn from Roberts)

and to bursæ under the tendons of the lumbrical muscles Dissection of the foot will reveal a large pocket between the flexor brevis digitorum and the flexor accessorius, and a small sac under the tendon of the tibialis anticus near its insertion into the medial cuneiform Common sites for the formation of adventitious bursæ are the fat pads anterior to the tips of both malleoli, between the tendon of the flexor brevis digitorum and the first metatarsal, just posterior to the sesamoids on

the outer surfaces of both the heads and bases of the fifth metatarsals, and in the superficial fascia of the plantar surface of the foot.

Bursitis means inflammation of a bursa. The etiology of bursitis is chiefly trauma, infection and metabolic disturbances. Trauma may be one acute or several minor traumata. Occupational trauma is important. Infections which may be local or focal, and infection combined with trauma or a toxemia combined with trauma are frequent causes. In cases of bone tumors or exostoses, bursitis is common. In 1868 Verneuil reported 4 cases of syphilitic bursopathy.

In an article based upon 50 cases of bursitis of the foot, Roberts describes a bursa as an enormously distended lymph space, the cells of the connective tissue walls of which have, as a result of constant friction, assumed the function of secreting a fluid more viscous than lymph to act as an antifriction medium between two surfaces gliding upon each other. From this it will be recognized that bursæ of various sizes may appear in areolar tissue anywhere in the body, and that the foot is a fertile field for their development.

Roberts believes that in certain areas bursitis may produce symptoms simulating those of weak-foot, metatarsalgia, calcaneal spur, fracture of a sesamoid under the head of the first metatarsal or arthritis of the ankle.

The symptoms and signs of bursitis of the foot may vary considerably. There may be local tenderness or tenderness plus fluctuation. The mass may be totally non-tender. In some cases it is hard or firm, in other cases, soft and movable. A local sense of heat may be noticed. There may be a sensation of crepitus, due to rice bodies. Articular motion may be free, or limited, in the adjacent joint.

Achillobursitis.—Bursitis between the Achilles tendon and the skin is a superficial inflammation, usually the result of pressure of the shoe. (See Chapter XI.)

Raising the heel of the foot by means of felt pads will change the position of the point of pressure and usually relieve the irritated area. (Fig. 175.) Rest in bed with the application of dressings saturated with hot boric acid or magnesium sulphate helps the circulation and combats infection. If these measures fail, operation is advisable. This consists of removal of the entire bursa and of any calcaneal spur in the involved region.

Albert described inflammation of the retrocalcaneal bursa. The terms "retrocalcaneal bursitis" and "achillodynia" are used synonymously. Albert believed the condition to be a cellulitis about the tendon or a periostitis due to trauma and attributed little importance to the part played by the bursa. It remained for Muller to fix the pathological responsibility upon the bursa, which he did by injections and incisions.

Hertzler described inflammation of the deep calcaneal bursa, which has often been mistaken for flat-foot Clinically, it is characterized by tenderness in the front part of the heel just in front of the attachment of the flexor group of muscles and lateral to the sustentaculum tali The patient does not indicate the exact point in giving the account of his complaint

Inflammation of the bursa under the head of the abductor hallucis muscle or of that between the flexor digitorum brevis and the flexor accessorius produces symptoms similar to those of painful weak-foot When bursitis develops between the tendon of the flexor brevis hallucis and the metatarsal bone, the disability is suggestive of a fracture of the sesamoid The differential diagnosis rests clinically upon the location of the point of tenderness Concomitant symptoms of bursitis of the foot are leg-fatigue and stiffness of gait, due to involuntary efforts to prevent pain caused by the normal use of the foot

Enlarged Intermetatarsophalangeal Bursæ—The intermetatarsophalangeal bursæ are four in number and are situated between the heads of the metatarsal bones, the three medial bursæ are almost constant, the fourth is only occasionally present

Gruber recognized these bursæ in 1795 Their clinical significance has been almost completely neglected

Probably the first to recognize disturbances of these bursæ clinically was Hertzler in 1926 Many of his cases had been previously treated for periods averaging from a few months to five years under the diagnosis of weak feet or metatarsalgia Relief of symptoms promptly followed the employment of such procedures as are commonly used to control inflamed bursæ

Next to call attention to this condition clinically was Roberts, in 1929 He reported 26 cases of metatarsal bursitis, of which 14 were cured by conservative and 12 by operative methods Royle noted the importance of these bursæ in producing metatarsalgia

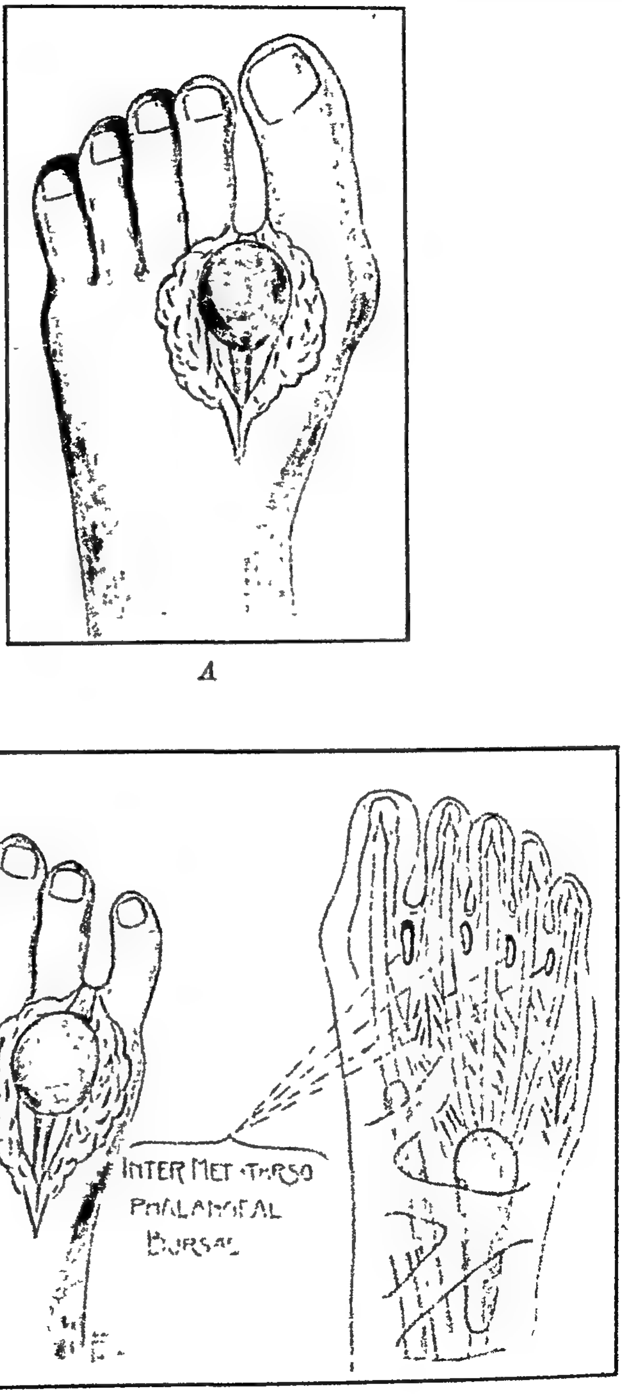
The differential diagnosis given by Lieberman depends upon

1 Circumscribed tenderness situated between the heads of the metatarsal bones,
2 Pain in the anterior portion of the foot when this area is compressed laterally,
3 Pain caused by hyperflexion of the toes, due to pressure on the bursæ through tension of the overlying tissue

Ganglion—A ganglion is a synovial sac lined by epithelium containing synovial fluid In the foot and ankle, the chief locations of ganglions are the regions of the first cuneiform-metatarsal joint, extensor hallucis longus tendon, and the external malleolus

The most important ganglion in the foot is found in the region of the dorsum of the first cuneiform bone The lesion is caused by the

mechanical pressure of a prominence of bone, usually due to "buckling" at the joint, upon the synovial endothelial cells, with the production of a sac. There is a point of irritation where a tendon passes over a prominence. The neighboring vessels and nerves may be traumatized.



A *B* *C*

FIG. 195.—*A* and *B* appearance of enlarged intermetatar-ophalangeal bursæ when exposed at operation. *C*, appearance of normal intermetatar-ophalangeal bursæ (*C*, Modified from Spalteholz.) (Lieberman, courtesy of Jour. Bone and Joint Surg.)

The tongue, laces, or eyelets of the shoe or a seam may cause irritation The injury may be from within or without (see Fig 182) In most cases the treatment is relief from pressure and irritation by skipping the offending laces and eyelets and padding of the shoes In some cases, surgical removal is indicated

The Origin of Rice Bodies in Bursal Sacs—Rice bodies are small masses, usually oval in shape, which are found attached or loose in the joint There may be a few of these objects or an enormous number There has been considerable discussion as to the origin of rice bodies Two theories are generally accepted as to the origin of these structures first, synovial fringes that are nipped off, and second, giant cells which come loose in the sac and cause coagulation about them

Mumford believes they are simply an accumulation of giant cells Fibrin from the clear or straw-colored fluid is deposited in layers upon the giant cell nucleus, giving the laminated structure seen on microscopic study The continuous liberation of giant cells from the sac wall accounts for the large number of "rice bodies" found In this theory, the origin of the masses is not that of a giant cell extruded from the deeper layers of the sac wall Rogers found that rice bodies were composed of tuberculous material, that they were at first attached to the wall of a tuberculous sac, and that very probably they were formed from the center of a tubercle

Treatment—In the treatment of bursitis of the foot and ankle, the problem is to protect the distended sac from pressure, or obliterate it surgically In many cases the symptoms will disappear if the leg is put at rest and wet dressings are applied Intermittent relief from weight-bearing is not sufficient Adhesive plaster strapping applied to prevent friction is helpful in moderate cases When conservative measures fail, surgical obliteration of the affected bursa is indicated This can often be done through a small incision permitting vigorous use of a sharp curette In cases of premalleolar bursitis, it is better to dissect out the entire fat pad and let the skin collapse over the fibrous expansions covering the joint

The bursæ which require surgical treatment most often are the retrocalcaneal bursa between the tendo Achillis and the tuberosity of the os calcis, and the calcaneal bursa between the tendo Achillis and the skin

The bursa should be dissected and removed *in toto*

The deep calcaneal bursa lies under the beginning portion of the abductor hallucis muscle extending laterally to the point of origin of the flexor brevis digitorum Beneath it, lies the sheath of the tibialis posticus The flexor hallucis longus and the flexor longus digitorum lie lateral to it The bursa is separated by these tendons from the long plantar ligaments It is best exposed by severing the abductor hallucis transversely 2 cm from its origin

Hertzler's operative technic is as follows: A line of skin 5 cm. long below the lower margin of the sustentaculum tali, anterior to the spine, is infiltrated. From this line, the deeper tissues are infiltrated by passing the needle over the long plantar ligament about the tendons of the muscles previously mentioned and into and about the heads of the short flexors. An incision is then made along the line of skin infiltration, extending through the skin and fascia just below and in front of the sustentaculum tali.

An elevator is then passed between the sheath of the tendon of the tibialis posticus tendon and the overlying soft parts. The bursa is reached at a depth of from 3 to 5 cm. Sometimes the bursa cannot be identified because of the presence of the anesthetic fluid in the tissues. Usually, however, the cavity can be discovered easily with the elevator. The site of the bursa is vigorously curetted even if no definite sac is made out. A small gauze drain is then passed into this area and allowed to remain in place for three or four days. This is done to continue the irritation produced by the curet. Hertzler formerly used an iodine pack, but later found it to be unnecessary.

A sufficient amount of soft tissue must be left to prevent postoperative adhesions of the tendon. When the posterior superior edge of the os calcis is enlarged, the process should be removed.

See Zadek operation (Fig. 173).

A short posterior splint should be applied for immobilization. Walking may be allowed as soon as the acute symptoms have subsided, and weight-bearing is permitted after nine days, the counter having first been removed from the shoe.

CHAPTER XVI

FRACTURES INVOLVING THE ANKLE AND ITS NEIGHBORING STRUCTURES

FRACTURES OF THE SHAFT OF THE TIBIA

Fractures of the shaft of the tibia are due usually to direct blows, falls, or torsion leverage, but may result also from indirect trauma produced by leverage such as occurs when the foot is caught and the body makes a rotatory movement. They may be transverse, oblique, spiral, linear, or comminuted.

The symptoms are pain, disability, and inability to stand. The signs are deformity, tenderness, and disability.

Kleinberg described a subperiosteal fissure fracture of the tibia which occurs in children as the result of a twist of the leg.

A fracture of the lower end of the tibia is frequently accompanied by a spiral fracture of the upper end of the fibula.

In fractures of the lower third of the tibia, non-union is common. The chief nutrient artery of the tibia enters the shaft posteriorly in its upper third and is directed obliquely downward. A fracture in the middle or lower third of the tibia may sever it. After most fractures of the middle third, the additional blood supply entering the tibia from the periosteum is sufficient for bone repair.

Conservative treatment consists in reduction followed by immobilization. If this is unsatisfactory, open replacement of the fragments is advisable. When only the tibia is fractured, the fibula acts as an excellent internal splint.

Spiral fractures of the tibia are produced by torsion and bending of the leg and are usually accompanied by fractures of the fibula often at a higher level. Such fractures may be produced by slipping on ice or by misstepping with one foot, while the other remains fixed on the ground. As the body turns in the attempt to regain balance, the whole weight is thrown on one leg, causing it to rotate on the thigh. Some difficulty may be experienced in maintaining the reduced position of the fragments in a spiral fracture. Putti or Parham-Martin bands which were of great value in maintaining the reduction of spiral or oblique fractures of the tibia (Fig. 199), have been largely replaced by stainless steel screws or plates.

(Congenital pseudarthrosis of the tibia is described in Chapter V.)

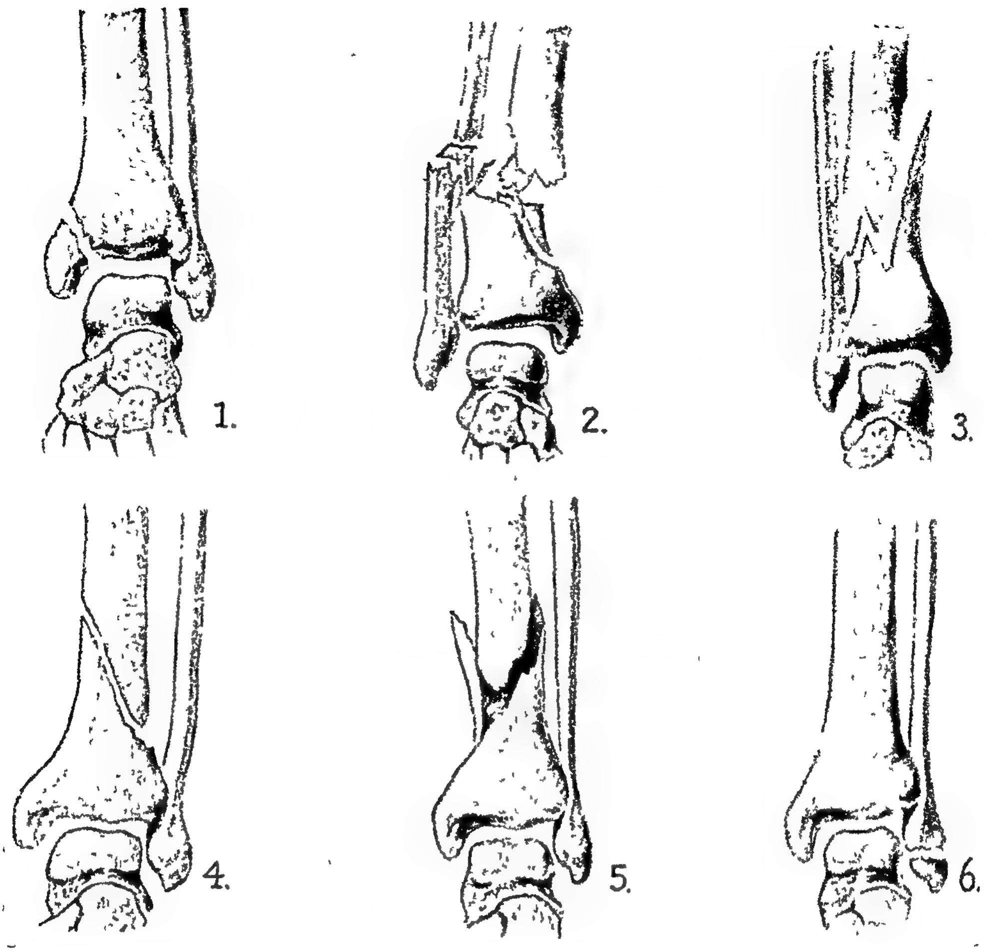


FIG. 196 —Variety of fractures in the lower third of the leg. *1*, fracture of the medial malleolus; *2*, comminuted fracture of the tibia and fibula at the junction of the lower and middle third; *3*, oblique fracture of the tibia, with outward displacement of the upper fragments; *4*, oblique fracture of the tibia without displacement; *5*, spiral fracture of the lower third of the tibia; *6*, fracture of the lateral malleolus (Eisendrath in Keen's Surgery, from Callander, Surgical Anatomy, courtesy of W. B. Saunders Company.)

COMPLICATIONS

The most common complications of fractures of the tibia and fibula, according to McBride,* are:

1. Traumatic arthritis:	3. Ankylosis:
(*a*) Knee	(*a*) Knee
(*b*) Ankle	(*b*) Ankle
(*c*) Tarsal bones	(*c*) Tarsal bones
2. Deformity:	4. Thrombosis
(*a*) Painful arch strain	5. Ischemic paralysis
(*b*) Malalignment of weight-bearing	6. Peroneal nerve paralysis

* Disability Evaluation, J. B. Lippincott Company, 1942.

SYMPTOMS

The symptoms which more often produce prolonged disability are

1 Pain	4 Atrophy
2 Swelling	5 Ankylosis
3 Paralysis	

Pain —Pain is often persistent in fractures of the tibia and fibula and may be permanent The extent of rarefaction of the bone and atrophy of the muscles will determine the time element and permanency Deformity is an index of the amount of pain to be anticipated

Paralysis —Ischemic paralysis is a disabling complication which may occur in the foot and leg Circular plaster casts or adhesive bands should not be allowed to produce constriction

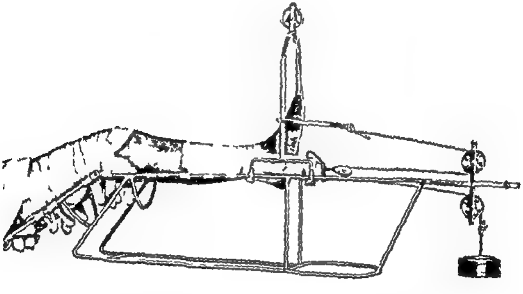


Fig 197 —Böhler Braun foot and leg splint with King's traction Illustrating traction on double fracture of tibia and fibula (Courtesy of DePuy Manufacturing Company)

Peroneal nerve paralysis may be caused by pressure of splints back of the head of the fibula A drop foot may greatly prolong the healing period Onset of this complication can be detected by loss of the patient's ability to dorsiflex the toes A drop foot splint should be worn until motor function returns Surgical exploration is necessary if the reaction of degeneration is present or improvement is not demonstrable

Swelling – Swelling persists normally for four or five weeks after removal of a plaster cast or splint Ecchymosis and infiltration of the

fascial planes are absorbed and replaced by scar tissue and adhesions which require *time and functional activity* for recovery to occur. Thrombosis or embolism of the veins may occur and produce edema of the entire leg.

It is advisable to apply an Unna's paste boot, elastic stocking or a resilient bandage after the removal of a cast from the foot or leg.

Pseudofracture of the Tibia.—Pseudofracture of the tibia occurs in children about ten years of age. It resembles an incomplete fracture. Roberts believes the condition to be closely allied to March fracture. Conservative treatment is usually successful.

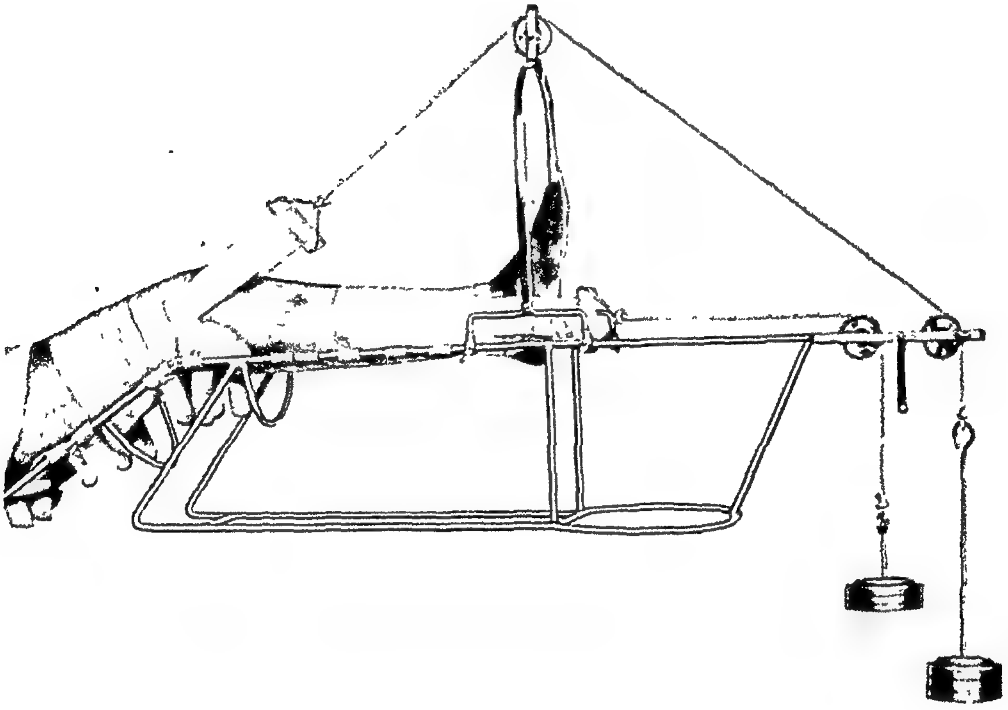


Fig. 198.—Illustrating simultaneous traction on femur and lower leg (Courtesy of DePuy Manufacturing Company.)

FRACTURES OF BOTH BONES OF THE LEG

Fractures of both the tibia and the fibula, so-called "b-b fractures," may occur at the same or at different levels. Manipulation should be attempted under local or general anesthesia and followed by the application of a plaster cast while traction is being made against the flexed knee. If manual traction is unsuccessful, skeletal traction is indicated.

R. W. Jones lays down the following rules for the treatment of both bone fractures of the leg:

1. The knee must be flexed to a right angle.

2 The limb should be held vertically in the line of gravity
3 Heavy traction must be maintained long enough for the application of plaster
4 Traction pins should not be left in the bone
5 The foot must be in the same plane of rotation as the patella
6 Lateral and anteroposterior angulation must be fully corrected
7 The apparatus should be easily portable and adjustable to any size of limb
8 The operator should be independent of assistants

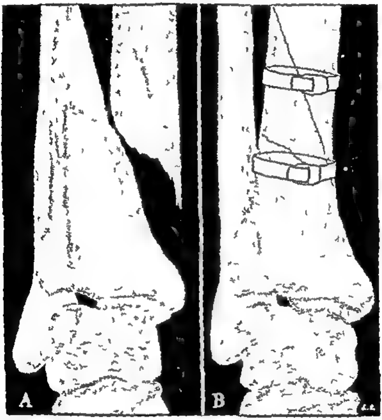


FIG 199 —Oblique fracture of the lower end of the tibia Reduction maintained by 2 Putti phosphor bronze bands Note hair-line reduction Redrawn from roentgenograms (This is the ideal situation for 2 or 3 stainless steel screws)

The essential factor in consolidation of bone surfaces is constant and absolute fixation of the fragments in contact with each other

Traction by means of a Steinmann pin introduced through the os calcis is effective In complicated fractures of the shafts of both bones traction-suspension should be tried Bohler, Anderson, Griswold, and others use wires, nails, and special apparatus

In some cases, open operation is necessary for reduction of the fragments and maintenance of contact If there is a tendency toward slipping, some form of internal splint such as sliding or onlay graft or

Martin or Putti bands screws or plates, is advisable. The Achilles tendon may require lengthening.

Deformities following union can be corrected by transverse osteotomy of the tibia and oblique section of the fibula (at a different level).

Delay of union is a common complication in fractures of bones of the leg, especially those occurring in the lower third. The stimulus to repair can be supplied by "protected" weight-bearing. This not only improves the impaired circulation but also stimulates the osteoblasts which produce callus.

In some cases a cast of zinc-gelatin paste may give sufficient support. The best appliance is the walking iron cast, or a caliper brace with ischial weight-bearing.

H. O. Thomas employed the "hammer and dam" method to stimulate union. This consists of intermittent submaximal stimulation of the fracture by light blows on the bottom of the heel.

The Tibiofibular Joint.—The tibiofibular joint is reinforced by two strong elastic ligaments, extending on the anterior and posterior surfaces between the lower ends of the tibia and fibula. They are the lateral malleolar ligaments and are put on the stretch when the broader anterior part of the talus is brought between the two bones, the stretching being possible on account of the elastic fibers of which the ligament is largely composed.

Fractures of the ankle constitute a serious injury in that interference with the function of an important weight-bearing joint so often results. Dickson's quadad are: Accurate diagnosis, exact reduction, efficient fixation, and careful after-treatment.

Fractures and dislocations of the tarsal bones include a variety of injuries which are uniformly disabling if improperly treated. Wilson believes that the keynote to success is, first, accurate and early diagnosis; second, reduction of bony deformity when possible; and third, the recognition of irreparable damage when it exists, and the treatment of this according to orthopædic principles.

Every fracture, no matter how simple, presents an individual problem to which the surgeon must seriously apply his judgment, resources and ingenuity. If fractures of the bones of the foot and ankle were given the same careful attention that is accorded to fractures of the bones of the wrist and hands, there would be fewer disabled, painful, distorted feet requiring reconstruction work, and demanding compensation. Meticulous care in the precise alignment of the bones comprising the ankle joint is imperative if one is to avoid subsequent pain and disability.

MacAusland correctly emphasizes the fact that it has been customary to treat the majority of these injuries by conservative methods, and to recognize operative indications only after conservative methods fail.

After this period of delay, the restoration of good function is difficult in cases of non-union, complicated by widening of the joint mortise and repair changes in the soft tissues. He recommends the use of internal fixation, which provides perfect approximation of the fragments and the accurate restoration of the joint mortise, which enhances repair of damaged soft structures and provides such good result, as the treatment of choice at the outset.

One is faced with two problems in treating these injuries. The first is the difficulty of anatomical reduction. The particular site and obliquity of the fracture-line, the type of displacement, tears of the ligamentous structures with avulsion of periosteal fragments, and the interposition of tissue between fragments are obstacles to accurate reduction by closed manipulative measures. The second problem is that of immobilization. It is difficult to maintain immobilization by plaster-of-Paris fixation. Even if accurate reduction can be effected, in some instances the fragments slip during convalescence as the swelling subsides.

An important factor in severe ankle injuries is the damage to the soft structures and the vessels. Under conservative management, necessitating long immobilization in plaster, excessive callus and scar tissue may develop in and around the joint. Extravasation of blood in the joint is absorbed slowly and leads to the formation of adhesions. Under operative treatment, the accurate reduction limits callous formation, adhesions are prevented by starting motion early, torn ligaments can be sutured and avulsed fragments of bone replaced and fixed in position, and blood clots can be evacuated from the joint.

In cases of trimalleolar fractures most surgeons recognize operative indications when the displaced posterior fragment includes a quarter or more of the tibial surface. In fractures of the anterior tibial surface the broken wedge of bone must be fixed in place. This fracture is nearly always comminuted.

In fractures of the fibula at the level of the articular surface, whether isolated or combined with a fracture of the tibial tip, the fracture line may be short and oblique, running upward and backward from the astragalus, or it may be a long fracture with its center at the joint. In these fractures the fibular fragment is usually displaced outward, taking the astragalus with it, thereby widening the joint mortise. In such fractures, internal fixation is obtained by means of a screw extending through the fibular tip into the shaft.

Fracture of the medial malleolar tip, whether isolated or combined with a fracture of the fibular end, is another fracture for which operative measures should more often be performed. Here the obstacle to closed reduction is a segment of fascia that lies between the malleolar fragment

and the shaft. Operative treatment is required to remove the interposed layer of tissue and fix the fragments in position.

Separation of the tibia and fibula as the result of rupture of the tibiofibular ligament, which causes a widening of the joint mortise, should be looked for in conjunction with any injury of the ankle. It may also occur as an isolated injury. A screw can be used to close the gap, thereby maintaining perfect approximation.

Boyd maintains that malunited bimalleolar fractures of the ankle can often be corrected satisfactorily by conservative operations which preserve motion in the joint. If arthritic changes are present, however, or if the articular surfaces of the joint are damaged during correction of the deformity, fusion of the ankle is preferable.

For malunited trimalleolar fractures, wherein the posterior fragment includes one-third or more of the lower end of the tibia, arthrodesis is indicated. In such cases, operations designed to preserve motion in the ankle usually fail.

Reconstructive Surgery in Patients With War Fractures of the Ankle and Foot.—A large number of patients with severe complicated fractures of the ankle and foot returned from overseas to every general hospital. Reconstructive bone surgery became an important phase of rehabilitation. The important objectives were: restoration of bone defects by grafts, correction of malalignments by osteotomies, and elimination of painful joints by fusion.

Most of the patients returned from overseas at least four to eight weeks after the occurrence of the fracture. Working on the general thesis that a living foot which has reasonable stability, sensation and comfort, even though it may be seriously deranged, is more desirable than an artificial foot, Snedecor outlined a plan of treatment.

If there was an open wound, the foot was soaked and bathed in sterile, warm, soapy water. The wounds were cleansed; sinuses were probed and irrigated. Loose or exposed pieces of bone and foreign material were removed. The dressing consisted of one layer of close-meshed gauze to cover the wound surface, with the usual gauze squares on top.

Next the foot was placed, as accurately as possible, in normal weight-bearing alignment under the tibia, with the ankle joint at an angle of 90 degrees. The calcaneus was placed either in a direct line or in slight inversion, but the foot itself was slightly everted. The contour of the foot and of the arches was molded into a relationship as nearly normal as possible and plaster was applied. The cast was lightly padded.

It was changed at intervals of one, two or three weeks, depending upon the comfort of the patient, the type of injury, and the amount of discharge. The soldiers preferred casts so that they could get up and go about, but occasionally a deep wound behaved better when the foot

was elevated in bed and the dressings were changed frequently. Surface wounds healed more rapidly when exposed to the air. Weight-bearing was often begun while the patient was still in plaster, by adding a walking iron. When rigid support could be abandoned, a flexible Unna's paste boot or elastic adhesive was applied.

The trial stage was a period of weight-bearing in a shoe with proper support. Over a period of weeks and sometimes of months, the patient was watched to see what Nature would accomplish toward banishing the limp and restoring painless weight-bearing.

Proper walking was insisted upon. Arch supports were frequently needed. A metatarsal crescent was often helpful in fractures of the tarsus and fore part of the foot, and a Thomas heel added an element of stability and control to the shoe.

The rehabilitation program was built upon three principles:

1. Walking is the best physical therapy for an injured foot.
2. A patient cannot walk on either a swollen foot or on one without adequate shoe support.
3. Swelling can be prevented by adequate elastic support, or it can be relieved by elevation and exercise.

The crusty foot with dry skin that had just come out of a cast was treated by whirlpool baths and oil massage. The foot that was bound up with scar tissue was helped by the softening effect of the baths and manipulation. Proper walking habits were taught. The therapeutic gymnasium had a number of helpful foot exercises, which included use of the bicycle, rowing machine, inclined boards, steps, and mirror walking.

The objective of treatment was a painless weight-bearing foot which would carry the soldier through a useful life. To obtain this, the following basic procedures were used, alone or in combination: (1) restoration of structural continuity where bony defects were present, (2) correction of weight-bearing malalignments, and (3) arthrodesis of joints which were painful or disintegrated.

Flexibility of the foot was secondary to good weight-bearing alignment. A painful joint was much more disabling than a stiff one. In general, however, a badly damaged foot proved to be handicapped, regardless of how much could be accomplished by skin grafts, bone grafts, joint fusions, or rearrangements of bone alignment.

A number of factors were evaluated in each case before surgery was undertaken.

1. The type of patient was taken into consideration, in an attempt to find out whether he was making a real effort to use his foot.

2. Accurate localization by examination and roentgenogram were employed to determine the exact cause and source of the pain. The

gait was analyzed and the line of the weight thrust down the limb into the foot was determined.

3. An estimate of a proposed operative result, was made, and if there was a reasonable anticipation of improvement, surgery was advised.

Relaxation of the tibiofibular synarthrosis following ankle sprain or fracture was one of the late complications of injury around the ankle joint. Operative interference was helpful in restabilizing the ankle joint. The excess of soft tissue between the two bones, which had become a bursa, was excised so that the bony surfaces came into lateral contact. Then a bolt was inserted transversely through the fibula and into the inner side of the tibia, about one-half inch above the joint. Nuts and washers were applied to bind these bones tightly together and to restore a rigid mortise to the joint. After eight weeks, the bolts were removed.

Ankle Injuries.—Disturbances of the fibular joint may easily be missed. This can be avoided if the simple rule is observed of having every "sprained" ankle in which there is no bony injury demonstrable radiographically, roentgen-rayed in inversion and eversion in the antero-posterior view. This will also detect subluxation of the astragalus.

Treatment consists of fixing the fibula to the tibia by means of a vitallium screw, through a short incision over the fibula, while the fibula is held firmly toward the tibia and the astragalus snugly against the internal malleolus.

In all postoperative cases Meekison applies a padded plaster, which is replaced by a non-padded cast in ten to fourteen days.

Subluxation of the Ankle Joint.—The ankle should be roentgen-rayed while the foot is held in forced eversion and inversion. The inversion projection reveals the displacement. If there is a tilt of the astragalus of more than 5 or 6 degrees (as compared with an identical view of the normal ankle), it can be assumed that one is dealing with a subluxation. Subluxation presupposes a complete rupture of at least the middle fasciculus of the fibular collateral ligament. The treatment includes immobilization of the ankle in mid-position for a period of eight to ten weeks. If adequate fixation for sufficient length of time is *not* carried out, the patient may be left with an ankle that is constantly "going over" and finally, tenodesis, using the peroneus longus tendon will be required.

Fractures of the Medial Malleolus.—For many years Meekison advocated open reduction and vitallium screw fixation of this very common fracture. At operation one invariably notes that there is interposition of soft tissue, periosteum, or fibres of the tibial collateral ligament and not infrequently a tiny fragment of bone, usually lodged

against the astragalus at the posterior end of the fracture line It is quite impossible to obtain adequate closed reduction of this fracture, either of the adduction or abduction type Open reduction is simple and rapid It is safe when the required aseptic technic is carried out Sufficient exposure is obtained so that by retraction, both anterior and posterior margins of the tibia may be visualized The fracture line is thoroughly cleaned out and all soft tissues cut away from the fracture level so that none will interpose during reduction and the "pattern" of the fracture line can be accurately fitted When this is done the congruity of the anterior and posterior margins of the fibula will be, noted While the malleolus is held in position by means of a sharp hook, a suitably long screw is passed through it into the shaft through a drill hole and it will be found that the malleolus remains firmly fixed in anatomical position The head of the screw is well buried in the ligaments at the tip of the malleolus The foot is immobilized in plaster in mid-position In from ten to fourteen days this is changed to a non-padded cast maintaining the same position, and to this is added a walking heel

Fractures of the Fibula With Diastasis, or With Rupture of the Internal Collateral Ligament—Mid-position should be a fixed rule except for fractures of the neck of the astragalus Using rapid setting plaster, and with the leg over the end or side of the table, it should be possible with heel of the palm pressure, to mold the fragments into position and apply a plaster with the foot in mid-position That is, with the foot neither in inversion nor eversion, and at right angles to the table

gait was analyzed and the line of the weight thrust down the limb into the foot was determined.

3. An estimate of a proposed operative result, was made, and if there was a reasonable anticipation of improvement, surgery was advised.

Relaxation of the tibiofibular synarthrosis following ankle sprain or fracture was one of the late complications of injury around the ankle joint. Operative interference was helpful in restabilizing the ankle joint. The excess of soft tissue between the two bones, which had become a bursa, was excised so that the bony surfaces came into lateral contact. Then a bolt was inserted transversely through the fibula and into the inner side of the tibia, about one-half inch above the joint. Nuts and washers were applied to bind these bones tightly together and to restore a rigid mortise to the joint. After eight weeks, the bolts were removed.

Ankle Injuries.—Disturbances of the fibular joint may easily be missed. This can be avoided if the simple rule is observed of having every "sprained" ankle in which there is no bony injury demonstrable radiographically, roentgen-rayed in inversion and eversion in the antero-posterior view. This will also detect subluxation of the astragalus.

Treatment consists of fixing the fibula to the tibia by means of a vitallium screw, through a short incision over the fibula, while the fibula is held firmly toward the tibia and the astragalus snugly against the internal malleolus.

In all postoperative cases Meekison applies a padded plaster, which is replaced by a non-padded cast in ten to fourteen days.

Subluxation of the Ankle Joint.—The ankle should be roentgen-rayed while the foot is held in forced eversion and inversion. The inversion projection reveals the displacement. If there is a tilt of the astragalus of more than 5 or 6 degrees (as compared with an identical view of the normal ankle), it can be assumed that one is dealing with a subluxation. Subluxation presupposes a complete rupture of at least the middle fasciculus of the fibular collateral ligament. The treatment includes immobilization of the ankle in mid-position for a period of eight to ten weeks. If adequate fixation for sufficient length of time is *not* carried out, the patient may be left with an ankle that is constantly "going over" and finally, tenodesis, using the peroneus longus tendon will be required.

Fractures of the Medial Malleolus.—For many years Meekison advocated open reduction and vitallium screw fixation of this very common fracture. At operation one invariably notes that there is interposition of soft tissue, periosteum, or fibres of the tibial collateral ligament and not infrequently a tiny fragment of bone, usually lodged

against the astragalus at the posterior end of the fracture line It is quite impossible to obtain adequate closed reduction of this fracture, either of the adduction or abduction type Open reduction is simple and rapid It is safe when the required aseptic technic is carried out Sufficient exposure is obtained so that by retraction, both anterior and posterior margins of the tibia may be visualized The fracture line is thoroughly cleaned out and all soft tissues cut away from the fracture level so that none will interpose during reduction and the "pattern" of the fracture line can be accurately fitted When this is done the congruity of the anterior and posterior margins of the fibula will be noted While the malleolus is held in position by means of a sharp hook, a suitably long screw is passed through it into the shaft through a drill hole and it will be found that the malleolus remains firmly fixed in anatomical position The head of the screw is well buried in the ligaments at the tip of the malleolus The foot is immobilized in plaster in mid-position In from ten to fourteen days this is changed to a non-padded cast maintaining the same position, and to this is added a walking heel

Fractures of the Fibula With Diastasis, or With Rupture of the Internal Collateral Ligament—Mid-position should be a fixed rule except for fractures of the neck of the astragalus Using rapid setting plaster, and with the leg over the end or side of the table, it should be possible with heel of the palm pressure, to mold the fragments into position and apply a plaster with the foot in mid-position That is, with the foot neither in inversion nor eversion, and at right angles to the table

CHAPTER XVII

FRACTURES OF THE BONES OF THE FOOT AND ANKLE

Some of the most important fractures are those occurring at the lower end of the fibula and tibia and those of the astragalus and the os calcis. Because it is common and often mistreated, the most serious fracture involving the foot and ankle is Pott's fracture. The next most serious is fracture of the os calcis.

FRACTURES OF THE BONES OF THE ANKLE JOINT

The ankle is a hinged joint, one end of which has a short, and the other a very long, lever. It is therefore subject to much stress and strain. Fractures of the ankle are classified by Cotton and Berg as: (1) outward dislocation, or Pott's fracture; (2) inward dislocation, or reversed Pott's fracture; (3) backward dislocation, or Cotton's fracture; and (4) upward dislocation.

Henderson's classification may be modified as follows: Group I. Isolated malleolar fractures. (*a*) Fracture of the internal malleolus. (*b*) Fracture of the external malleolus. (*c*) Fracture of the posterior malleolus. (*d*) Fracture of the anterior margin of the tibial articular surface.

Group II. Bimalleolar fractures. (*a*) Fracture of the internal and external malleoli without displacement of the talus. (*b*) Fracture of the internal and external malleoli with displacement of the talus (Pott's fracture).

Group III. Trimalleolar fractures. (*a*) Fracture of the internal, external, and posterior malleoli with displacement of the astragalus laterally, posteriorly, or both.

There are few fractures in which complete correction of deformity is more important than a fracture about the ankle, for if the body weight does not pass through the middle of the astragalus there is danger of disability. For normal function, the astragalus must remain in a fixed position secured by the malleoli.

The treatment of fractures of the ankle may be divided into four stages: reduction, retention, mobilization, and weight-bearing or function. The consensus of authorities today is that conservative measures which usually gave "satisfactory" results, should be replaced by early open operation, in certain situations.

After reduction, the fragments are maintained in position by plaster-of-Paris (If this is not possible, internal or external skeletal fixation are advised) If signs of circulatory constriction are evident, the cast should be split at once to prevent ischemic paralysis

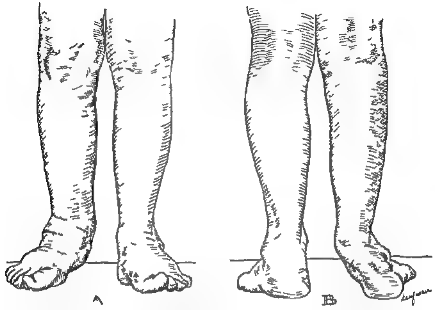


FIG 200 —Traumatic flat foot (right) due to old Pott s fracture improperly treated resulting in deformity disability and pain *A* Front view *B* Rear view (Drawn from photographs)

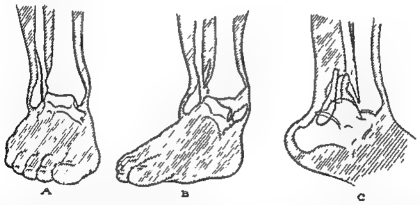


FIG 201 —Pott s fracture by eversion *A* Oblique fracture of the lower fibula *B* By a continuation of eversion the internal malleolus is torn off *C* Extreme eversion tears off with the lower fibula the posterior margin of the tibia A lateral view shows that the foot has become dislocated backward Sketches after roentgen ray plates Peter Bent Brigham Hospital (From Homan s Textbook of Surgery 4th edition courtesy of Charles C Thomas Publisher, Springfield)

Passive movements, heat, massage, and contrast baths prevent atrophy, contracture, and periarticular adhesions Active, carefully supervised movements should be instituted as early as possible, but weight-bearing should be forbidden until the fracture is solid As a

rule it is advisable to raise the inner border of the shoe to prevent valgus. In some cases, a brace with an outside iron and an inside T-strap may be necessary. Weight resistance exercises are very helpful.

In cases of fracture of the internal and external malleoli without displacement (and no possibilities of interposition of soft tissue), rest of the foot for two or three days in a sheet-wadding-bandage, and a compression dressing is advisable. This should be followed by adhesive plaster strapping with the foot in dorsal flexion and adduction and the toes in plantar flexion. After from three to six days, weight-bearing and walking in a shoe with a heel raised $\frac{1}{4}$ inch on the inner border, should be encouraged. The adhesive dressing should be renewed every four or five days for six weeks.

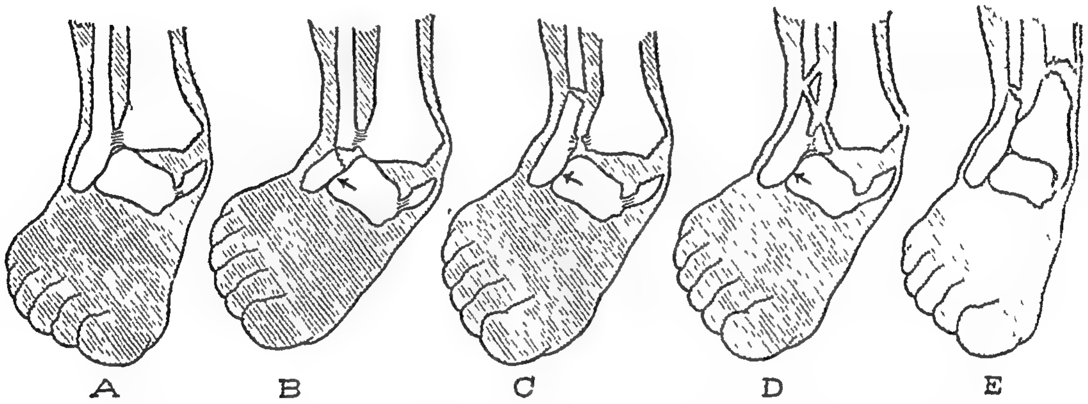


Fig. 202.—Pott's fracture by abduction. *A*, The internal malleolus is torn away. *B*, Abduction continuing and the tibio-fibular ligaments holding, the external malleolus is broken off. *C*, The tibio-fibular ligaments give way, transferring the breaking strain upon the fibula to a part about 8 cm. above the ankle. *D*, The same effect as *C*, but a fragment of tibia is torn off by the tibio-fibular attachment. *E*, The internal malleolus holds, the external holds, and both bones are broken at a higher level. (From Homan's Textbook of Surgery, 4th edition, courtesy of Charles C Thomas, Publisher, Springfield.)

POTT'S FRACTURE

The most important fracture in the region of the ankle is Pott's fracture, a break of the lower end of the fibula, usually about $1\frac{3}{4}$ inches above the tip, with lateral displacement of the ankle joint. Henderson reports that in fractures of the lower 3 inches of the fibula with rupture of the internal lateral ligament, fracture of the internal malleolus, or even slight deformity at the ankle joint, he finds either eversion alone or eversion combined with posterior displacement of the foot. Pott's fracture is produced by violent eversion in which the astragalus is thrown against the external malleolus. The ligaments binding the fibula to the tibia remain intact and act as a fulcrum, and the shaft of the fibula breaks at the weakest point just above the ankle. The astragalus is displaced backward as well as outward. The cause

is a twisting strain, leverage, or a direct blow. The symptoms are pain, swelling, tenderness, inability to stand or walk, and deformity.

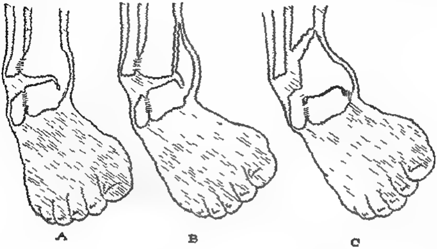


FIG 203.—Fractures by adduction at the ankle. *A*, The external malleolus is torn off. *B*, The strain falls on the internal malleolus and chips a piece from the lower end of the tibia. *C*, All ligaments and malleoli hold and both bones are broken above the ankle. (From Homans's Textbook of Surgery, 4th edition, courtesy of Charles C Thomas, Publisher, Springfield.)

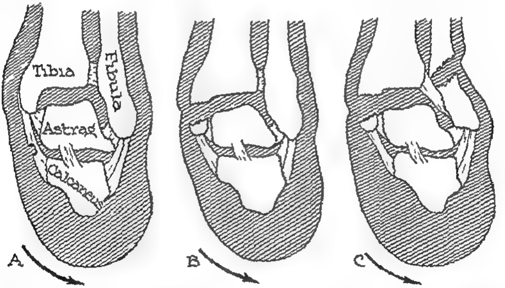


FIG 204.—Schematic frontal sections through the right ankle to show the mechanism of sprain and fractures caused by abduction and eversion of the foot. *A*, An abduction (eversion) sprain in which the deltoid (medial) ligament is torn. *B*, An abduction (eversion) fracture of the tip of the medial malleolus, the ligaments remaining intact. *C*, A typical abduction and eversion fracture with fracture of the shaft of the fibula. (Modified from Testut and Jacob.) (Redrawn from Callander, Surgical Anatomy, 2d ed., courtesy of W. B. Saunders Company.)

A person with an improperly reduced Pott's fracture cannot walk without pain in the ankle and at the inner side of the knee. In some cases there is knock-knee and flat-foot.

The treatment of Pott's fracture consists in immediate reduction by *manipulation* under local or general anesthesia and retention of the foot, ankle, and leg in plaster-of-Paris with the foot at a right angle and in varus. The deformity should be first increased by abduction

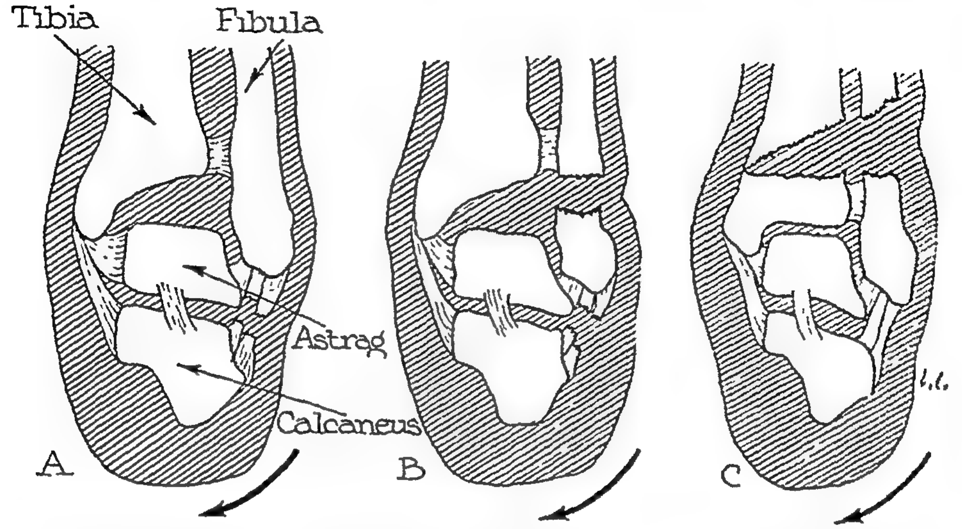


FIG. 205.—Schematic sagittal sections through the right ankle to show the mechanism of sprain and fracture (reversed Pott's) caused by adduction and inversion of the foot. *A*, Sprain from a tear of the lateral ligament *B*, Lesion in which the lateral ligament is lacerated and the lateral malleolus is wrenched off. *C*, Transverse supramalleolar fracture. (Modified from Testut and Jacob) (Redrawn from Callander, Surgical Anatomy, courtesy of W. B. Saunders Company.)

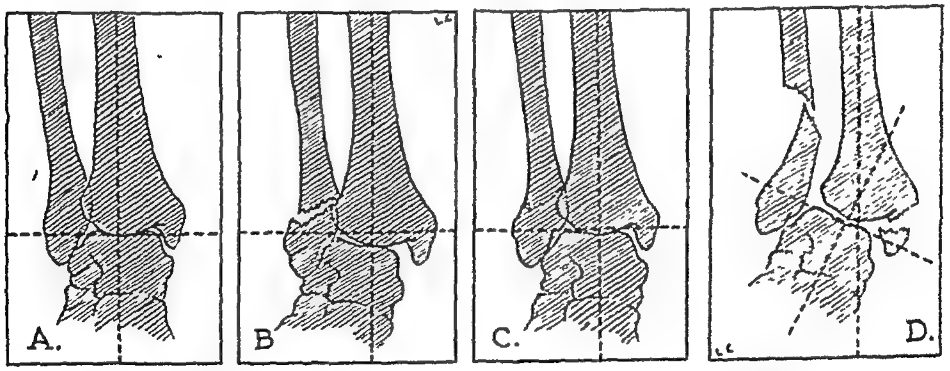


FIG. 206.—*A*, Plotting of the normal weight-bearing central axis line of the tibia as it normally bisects the astragalus. *B*, The abnormal weight-bearing line of the tibia does not bisect the head of the astragalus when the astragalus is dislocated externally. If the astragalus is not reduced the functional result will be poor. *C*, Correct reduction of astragalus and restoration of normal weight-bearing line. *D*, Typical Pott's fracture. (Redrawn from E. H. Skinner)

or eversion of the foot. Then, while traction is being made in the long axis of the body, the foot ... be brought into ...rsion and dorsiflexion. The foref... be everted sli... t the big toe rests on the ground ...he longitudina... foot and leg in this position sh... ...orated in a ...aris cast

extending from the toes to a point above the knee joint A walking iron should be incorporated in the cast, and walking should be encouraged immediately (See Fig 63) At the end of four or five

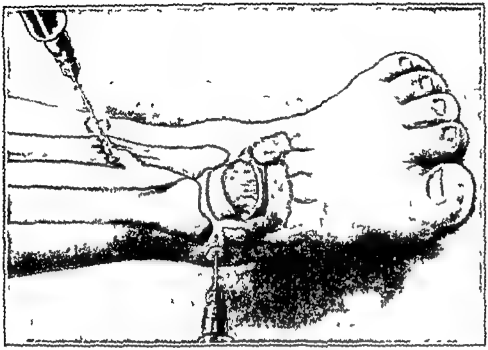


Fig 208

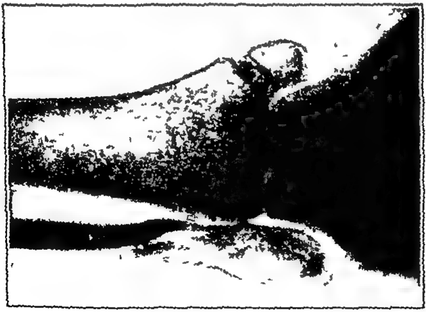


Fig 207

Fig 207 —Pott's fracture Should have been treated by immediate surgery

Fig 208 —Pott's fracture Infiltration anesthesia with novocain is satisfactory in the management of this type of fracture as well as fractures of the tibia and fibula higher up The lower end of the tibia and that of the fibula are often involved and both fracture gaps should be infiltrated (Courtesy of the Winthrop Chemical Company Inc)

days the cast may be cut down to the garter line At the end of two or three weeks it should be bivalved to permit massage and manipulation When the patient is ready to walk, a high-laced shoe with a modified heel which is longer and higher on the inner than on the outer

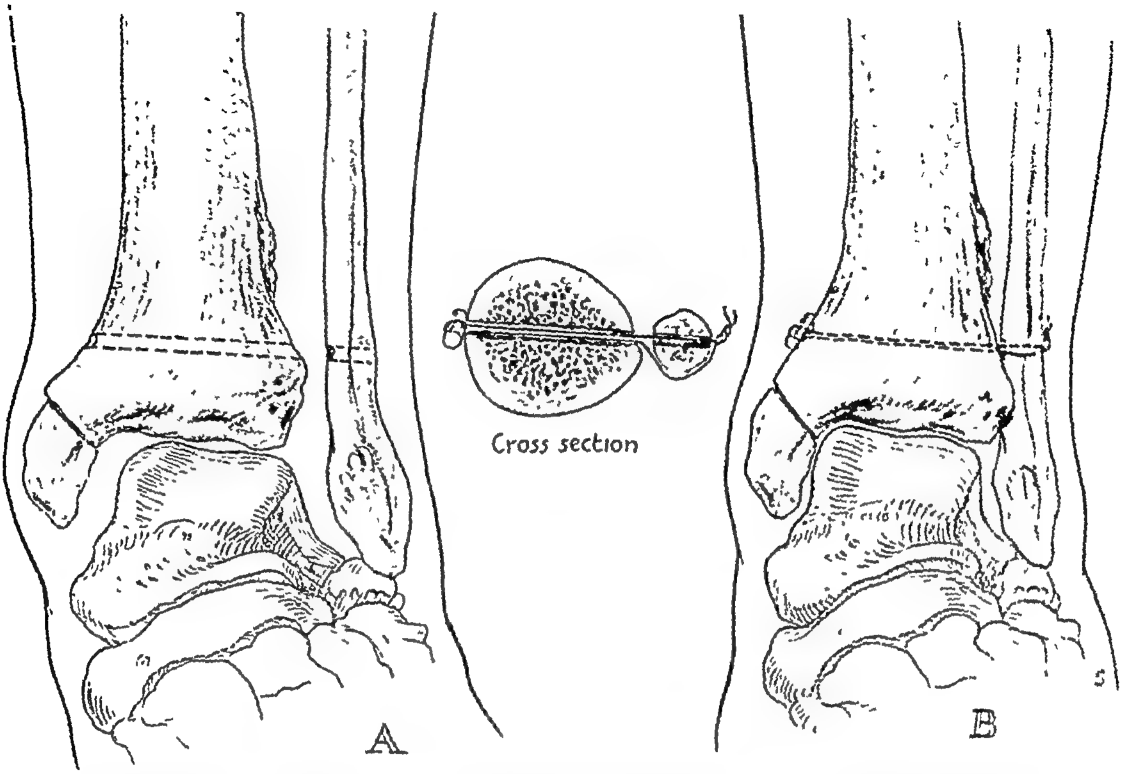


FIG. 209.—Fracture of internal malleolus with diastasis of tibia and fibula and lateral displacement of astragalus. *A*, Osteotomy and restoration of normal position of internal malleolus, hole drilled transversely through tibia and fibula for passage of wire loop. *B*, Fibrous tissue removed from between astragalus and internal malleolus and diastasis corrected, placing astragalus in normal position. (Campbell, Operative Orthopedics, courtesy of the C. V. Mosby Company.)

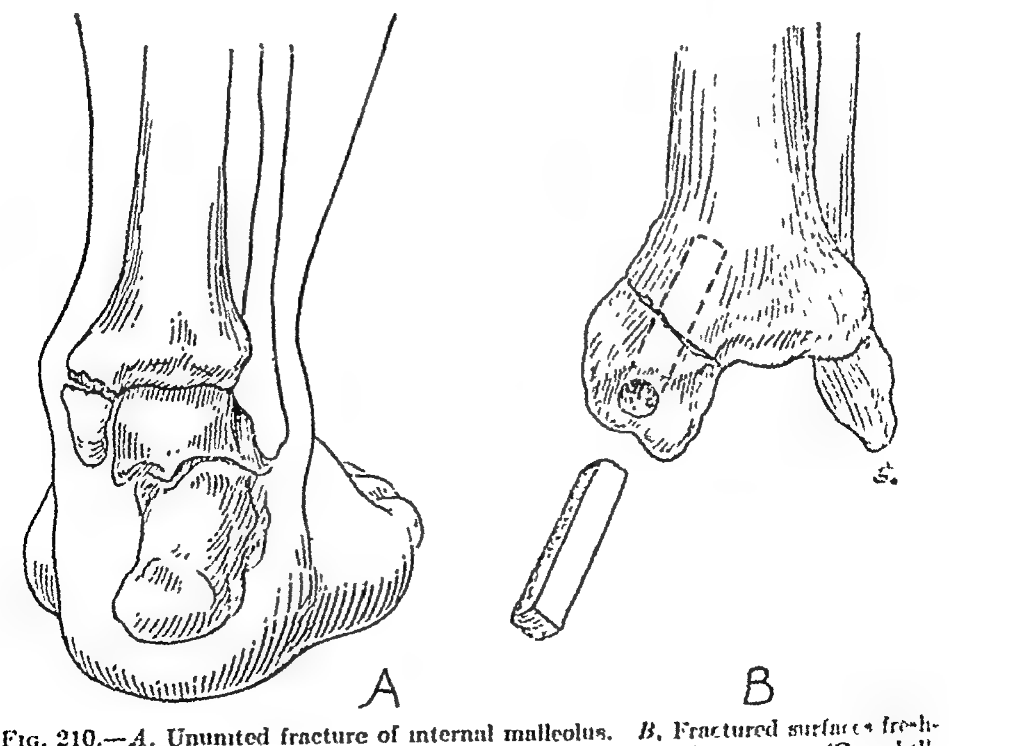


FIG. 210.—*A*, Ununited fracture of internal malleolus. *B*, Fractured surfaces freshened, reduced, and fragments held in place by autogenous bone peg. (Campbell, Operative Orthopedics, courtesy of the C. V. Mosby Company.)

border should be worn. The usual prolongation of the heel is about ¾ inch, and the increase in its height about ⅛ inch.

Practically all Pott's fractures can be reduced satisfactorily by conservative measures, but if the position cannot be maintained, surgery is warranted. Open reduction and internal fixation of the fibula usually assure a good result.

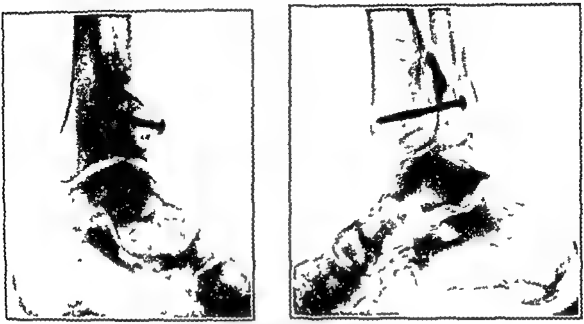


FIG. 211.—A stainless steel screw for fracture of the medial malleolus.

FRACTURE OF THE POSTERIOR TIBIAL MARGIN

Fracture of the "posterior malleolus," or posterior third of the joint surface of the tibia, is caused by the impact of the astragalus on the posterior border of the tibia or avulsion by the posterior peroneal ligament. It frequently results from catching the heel on the edge of a stair or curb. In such an accident the foot is hyperextended and the hyperextension is increased by the weight of the body thrown on the foot. The fractured posterior malleolus and the astragalus are forced backward and upward.

Following a fracture of this type there is subluxation of the foot, the heel appears to be elongated, and the anterior margin of the tibia is prominent. In addition to the backward dislocation of the foot, there is usually a certain degree of valgus. The loss of the posterior support of the foot causes disability.

The treatment of fracture of the posterior malleolus consists in reducing the astragalus to its proper position and immobilizing the foot. To replace the astragalus downward, traction should be made on the foot and followed by alternate movements of extension and

Fig. 212.—Fracture of posterior lip of tibia with backward dislocation of foot.

Fig. 213.—Traumatic disorganization of ankle joint.

Fig. 214.—Fracture of the internal malleolus, irreducible by manipulative measures. (Photograph, courtesy of MacAusland.)

Fig. 215.—Through and through screw for diastasis of tibia and fibula

Fig 216 —Lateral dislocation of ankle joint

Fig 217 —Stainless steel screw in lower end of fibula

Fig 218 —Fracture of posterior tip of tibia with backward dislocation of foot

flexion. The foot should then be immobilized in forced dorsal flexion making an acute angle with the leg.

FRACTURE OF THE ANTERIOR TIBIAL MARGIN

A fracture of the anterior portion of the lower end of the tibia may be caused by sudden violent hyperflexion of the foot such as occurs when in stepping up on a curb or stair the foot slips off and is forced upward and the astragalus is forced forward and upward.

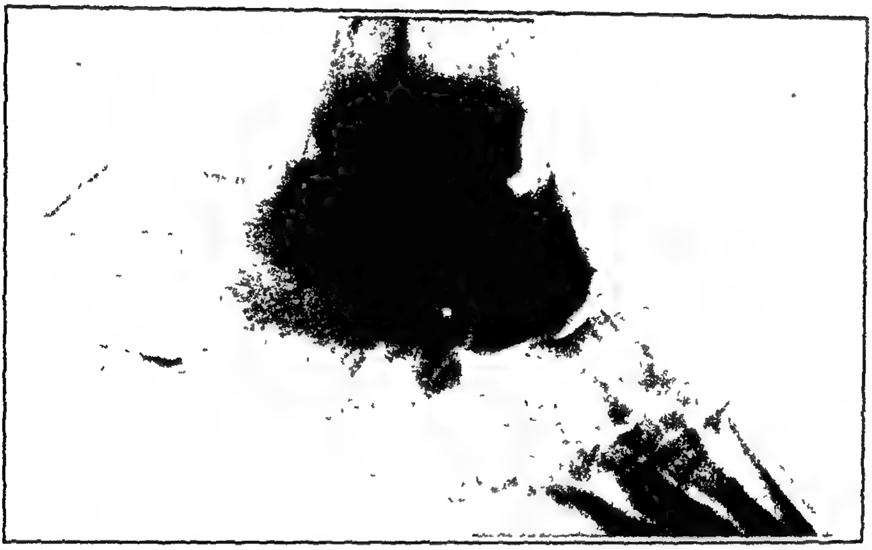


FIG. 219.—Compression fracture of the astragalus due to an injury sustained when a man fell from a ship mast and landed on his feet. At least ten years elapsed before the roentgenogram was made. At present there is a severe deformity of the astragalus with traumatic arthritis involving the astragalo-scaphoid, the calcaneal, subastragalar and the calcaneal-scaphoid. Note the calcaneal spur. Treatment was astragalectomy, combined with a Hoke type of stabilization

If the fragment is large and so situated that anatomical approximation by manual force is impossible, open reduction is indicated to prevent traumatic arthritis.

In the treatment of a dislocated fragment of the lower end of the tibia, Lounsbury and Metz drive a nail through the fragment.

COTTON'S (TRIMALLEOLAR) FRACTURE

In the trimalleolar fracture, the posterior lip of the articular surface of the tibia is fractured and displaced with resulting backward and lateral displacement and eversion of the foot. A fracture of this type is therefore more likely to produce serious disability than the bimalleolar fracture with only lateral displacement. Posterior displacement of the entire foot causes serious incapacity if uncorrected.

The indications for open reduction depend upon the size of the tibial fragment and the incongruity of the articular surfaces If apposition and alignment of the tibia and astragalus cannot be maintained and the displacement will eventually interfere with the function of the ankle joint, open operation is advisable, for if it is not performed the pain will usually persist and subsequent fusion may be required Henderson advises that trimalleolar fractures with a large posterior malleolar fragment be subjected to early open operation

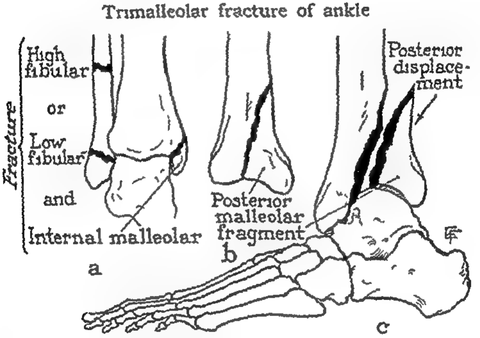


FIG 220 —Henderson's trimalleolar fracture of ankle (Henderson and Stuck courtesy of Jour Bone and Joint Surg)

Trimalleolar Fracture of the Ankle Joint—A trimalleolar fracture is a serious injury of the ankle joint, consisting of a fracture of the posterior inferior articulating surface of the tibia (the posterior surface of the roof of the ankle joint), and a posterior dislocation or subluxation of the foot The astragalus is pulled upward and backward and with the tibia and fibula being shunted forward and coming to rest on the neck of the astragalus instead of on the trochlea There is also an extensive tearing of the ligaments of the ankle joint as well as the soft tissues as indicated by the excessive swelling, edema, and ecchymosis above the ankle and foot The larger the posterior tibial fragment, the greater generally the amount of displacement, and therefore the more difficult the reduction and the maintenance after reduction

Ashurst gives an excellent description of this condition This fracture is commonly referred to as "Cotton's fracture" although it appears to have been first reported by Sir Astley Cooper in 1822,

because Dr. F. J. Cotton observed and accurately described it in a series of cases studied between 1903 and 1915. He emphasized the important details of this type of fracture.

The incidence of trimalleolar lesions has been reported as 16.5 per cent of ankle fractures by Henderson who stated that only one case in his first series required open reduction. This posterior articulating margin of the tibial plafond (arch, ceiling, dome) is longer and projects farther downward than is generally supposed (both Destot and Henderson have termed it the "posterior mallelous") and is therefore particularly prone to injury.

It is evident that the mechanics of production of this fracture, which is one of the most frequent of all fractures of the ankle involves not only a thrust outward of the anterior border of the external malleolus, but also a full inward thrust on its posterior band of the external lateral ligament. It is, properly speaking, a spiral fracture produced by torsion, the obliquity of application varying greatly, but acting always higher on the posterior surface of the fibula than on its anterior surface. The line of fracture passes through and involves the inferior tibiofibular joint. Almost invariably, its lower and anterior end extends to the external malleolus often just below the tibial plafond, sometimes as far down as the very tip of the malleolus.

Thus, in practically every instance the anterior inferior tibiofibular ligament remains intact, for, even if partially ruptured, there results no real diastasis between tibia and fibula. At most, the lower fragment, comprising that part of the fibula posterior to the attachment of the anterior tibiofibular ligament, rolls outward and slightly backward around the unruptured posterior tibiofibular ligaments as a hinge.

The foot being extended or plantar flexed with some outward rotation, the astragalus is driven against the posterior articulating margin of the tibia (posterior malleolus) which is broken off, and when the action of the force has continued after this fracture has taken place, a posterior dislocation of the astragalus may result.

The greatest difficulty is encountered in those cases in which more than one-third of the lower articulating surface of the tibia is fractured.

In the treatment of each of these types, accurate anatomic alignment of the fragments from the moment of reduction until union has taken place must be obtained and maintained.

Faske and Shapiro discuss 3 classes of cases.

First Degree.—In this class, without much posterior displacement if the treatment is instituted immediately, *i. e.*, before much effusion and subcutaneous hemorrhage has taken place, manual reduction under anesthesia will suffice.

The reduction is effected by flexing the injured leg on the thigh and

the thigh on the abdomen This relaxes the gastrocnemius and Achilles tendon The heel being placed in the operator's palm, the assistant makes countertraction on the thigh while the operator pulls and makes traction on the heel, pulling the foot in the direction of the long axis of the tibia, and then upward A characteristic grating sensation is felt as the astragalus slips into the mortise of the joint The foot is then dorsiflexed to about 100 degrees and pressure is made over both malleoli to reduce the width of the ankle joint, thus approximating the fractured malleoli A cast is then applied extending from below the knee to the toes, maintaining this degree of dorsiflexion and slight inversion of the foot No weight-bearing is permitted for at least eight weeks although a walking iron may be used

Second Degree —A general or local anesthetic is administered and manual manipulation is attempted as previously described If this fails, skeletal traction is attempted, and sometimes a tenotomy of the Achilles tendon is performed For the skeletal traction, the Kirschner wire or solid Steinmann pin is used

Employing the MacMillan apparatus and skeletal distraction Fiske and Shapiro have never had recourse to open operative treatment in a series of 33 trimalleolar fractures The distraction method works on the principles that the impaction is broken up, the fragments are separated and the posterior displacement of the foot is reduced This permits accurate reduction, accurate control of the involved osseous structures, firm fixation (a plaster cast is easily applied without fear of disturbing the alignment of the fragments or disturbing the mortise of the joint) and hospitalization is reduced Early ambulatory treatment may be instituted by the incorporation of a walking iron into the cast

Procedure —To obtain local anesthesia, 10 cc of 2 per cent procaine solution is injected into the upper one-third of the leg over the tibia, about three fingers' breadth below the knee joint, posterior to the tibial tubercle A hole is drilled through the tibia at this point, and then a $\frac{5}{32}$ inch Steinmann pin is inserted A drill is used here because the bone at the upper end of the tibia is very hard This procedure greatly reduces the trauma, and the pin is inserted through the middle one-third of the os calcis This latter site is chosen for the following reasons If an imaginary line were to be drawn from the tip of the external malleolus to the tip of the heel, and this line were divided into three equal parts, the following would be the anatomical distribution resulting the proximal one-third is the location of the tibial vessels, the distal one-third consists only of soft tissue, and the middle third, where the bone is most superficial and free from any significant structures, is hence ideally suited for insertion of the pin

With the pins in place, collodion and sterile gauze pads are spiked over the pins, sealing the skin surfaces about the protruding pins. Four ferrules are now slipped over the protruding ends of the pins and the ferrules are then placed on the MacMillan apparatus. The pin through the os calcis lies on a level ½ inch lower than the long axis of the tibia.

With everything now in readiness for reduction, the necessary mechanical adjustments are made. Impaction must be broken up and the fragments separated, checking by frequent use of the fluoroscope. While traction is being made, an assistant makes firm pressure on the shaft of the tibia as the foot is being dorsally flexed. When traction is completed the foot may be elevated and when the astragalus is opposite the articulating surface of the tibia the traction is released, and the astragalus then enters the mortise of the ankle joint.

The foot is now inverted or elevated and pressure is made over the fractured malleoli molding them into satisfactory alignment, thereby reconstructing the mortise. To obtain this reduction, the fragments must be clear of the joint surfaces. If too much traction has been applied, free bleeding is noted from the site of the pin through the os calcis. However, when the traction is relaxed, the bleeding ceases.

Retention and immobilization are now maintained by a cast extending from the upper third of the thigh to the toes with the pins incorporated into the cast. The foot is held at 100 degrees dorsiflexion, in inversion or eversion as required for the fractured malleoli. When the cast has hardened, the limb is removed from the apparatus. Th patient is allowed out of bed the next day. The pins may re *situ* ten days to three weeks or longer.

Third Degree.—In this type there is a complete posterior d of the foot. The treatment is the same except that freq necessary to do a tenotomy of the tendo Achilles before a sa reduction is obtained.

Postoperative Care.—Within ten days after the reduction plication of the cast, there occurs subsidence of the swelling an and this is followed by an atrophy of the soft parts, converting fitting plaster cast into a loose covering. If one is not alert minute details, the perfectly reduced fracture may undergo red ment and result in a malunion at the end of six weeks. Fr roentgen-rays are therefore essential. Too early weight-bearin a loose cast almost always result in displacement of fragments

In order to obtain ultimately good results, the pins should corporated in the cast for three or four weeks or longer, obviating any displacement of the fragments despite subside swelling and atrophy of the soft parts.

FRACTURES OF THE BONES OF THE FOOT

If fractures of the bones of the foot were given the careful attention accorded fractures of the hand, there would be fewer disabled, painful feet, requiring compensation

FRACTURES OF THE TARSAL BONES

Fractures of the bones of the foot are important causes of industrial disability They are usually caused by a fall from a height or the impact of a heavy object which crushes the foot Sprains may be complicated by a slight fracture which may be overlooked

Fractures of the tarsal bones are frequently followed by arthritis and aseptic necrosis Therefore they require accurate reposition and long-continued supervision, and, in many cases, a support should be worn for months

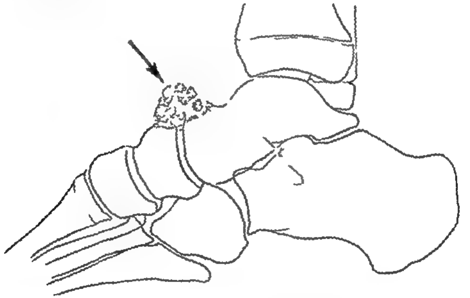


Fig 221 —Exostosis and traumatic arthritis at dorsal surface of astragalo-scaphoid joint

FRACTURES OF THE ASTRAGALUS

Fractures of the astragalus often produce severe disability They are usually due to crushing injuries Open reduction is often necessary If there is malunion or non-union with pain and disability, astragalectomy is indicated

The condition known as "Shepherd's fracture" occurs in the posterior part of the astragalus where it articulates with the os calcis Bettazzi was able to produce it in from 75 to 80 per cent of attempts on cadavers by forcibly striking the heel of the hyperextended foot It is probably the result of a shearing or crushing mechanism

With the pins in place, collodion and sterile gauze pads are spiked over the pins, sealing the skin surfaces about the protruding pins. Four ferrules are now slipped over the protruding ends of the pins and the ferrules are then placed on the MacMillan apparatus. The pin through the os calcis lies on a level $\frac{1}{2}$ inch lower than the long axis of the tibia.

With everything now in readiness for reduction, the necessary mechanical adjustments are made. Impaction must be broken up and the fragments separated, checking by frequent use of the fluoroscope. While traction is being made, an assistant makes firm pressure on the shaft of the tibia as the foot is being dorsally flexed. When traction is completed the foot may be elevated and when the astragalus is opposite the articulating surface of the tibia the traction is released, and the astragalus then enters the mortise of the ankle joint.

The foot is now inverted or elevated and pressure is made over the fractured malleoli molding them into satisfactory alignment, thereby reconstructing the mortise. To obtain this reduction, the fragments must be clear of the joint surfaces. If too much traction has been applied, free bleeding is noted from the site of the pin through the os calcis. However, when the traction is relaxed, the bleeding ceases.

Retention and immobilization are now maintained by a cast extending from the upper third of the thigh to the toes with the pins incorporated into the cast. The foot is held at 100 degrees dorsiflexion, in inversion or eversion as required for the fractured malleoli. When the cast has hardened, the limb is removed from the apparatus. The patient is allowed out of bed the next day. The pins may remain *in situ* ten days to three weeks or longer.

Third Degree.—In this type there is a complete posterior dislocation of the foot. The treatment is the same except that frequently it is necessary to do a tenotomy of the tendo Achilles before a satisfactory reduction is obtained.

Postoperative Care.—Within ten days after the reduction and application of the cast, there occurs subsidence of the swelling and edema and this is followed by an atrophy of the soft parts, converting a snug-fitting plaster cast into a loose covering. If one is not alert to these minute details, the perfectly reduced fracture may undergo redisplacement and result in a malunion at the end of six weeks. Frequent roentgen-rays are therefore essential. Too early weight-bearing and a loose cast almost always result in displacement of fragments.

In order to obtain ultimately good results, the pins should be incorporated in the cast for three or four weeks or longer, thereby obviating any displacement of the fragments despite subsidence of the swelling and atrophy of the soft parts.

FRACTURES OF THE BONES OF THE FOOT

If fractures of the bones of the foot were given the careful attention accorded fractures of the hand, there would be fewer disabled, painful feet, requiring compensation

FRACTURES OF THE TARSAL BONES

Fractures of the bones of the foot are important causes of industrial disability They are usually caused by a fall from a height or the impact of a heavy object which crushes the foot Sprains may be complicated by a slight fracture which may be overlooked

Fractures of the tarsal bones are frequently followed by arthritis and aseptic necrosis Therefore they require accurate reposition and long-continued supervision, and, in many cases, a support should be worn for months

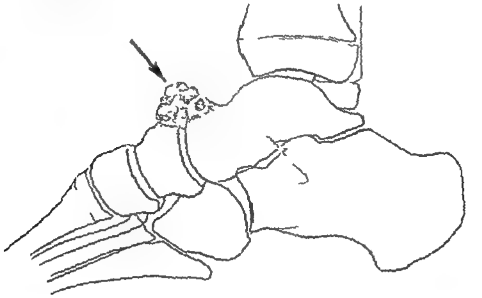


Fig 221 —Exostosis and traumatic arthritis at dorsal surface of astragalo-scaphoid joint

FRACTURES OF THE ASTRAGALUS

Fractures of the astragalus often produce severe disability They are usually due to crushing injuries Open reduction is often necessary If there is malunion or non-union with pain and disability, astragalectomy is indicated

The condition known as "Shepherd's fracture" occurs in the posterior part of the astragalus where it articulates with the os calcis Bettazzi was able to produce it in from 75 to 80 per cent of attempts on cadavers by forcibly striking the heel of the hyperextended foot It is probably the result of a shearing or crushing mechanism

This fracture is often confused with the os trigonum, an adventitious bone in the same region. The differential diagnosis depends upon the roentgenographic findings. If an os trigonum is present, the line of separation is distinct and regular, whereas in Shepherd's fracture it is narrower, opaque, and irregular. The os trigonum is often bilateral, whereas Shepherd's fracture is unilateral. In Shepherd's fracture, non-operative treatment is usually successful, but occasionally excision is indicated because of long-continued pain and failure of callus formation.

In all cases of fracture of the astragalus there is danger of traumatic arthritis involving the ankle and subastragalar joints. For this reason, motion should be instituted as early as possible. To preserve the normal contours of the ankle, it is essential to mold both the fragments and the ankle.

If the astragalus is tilted, there is danger of producing varus or valgus deformity of the foot, which may cause severe pain, especially in walking over uneven surfaces.

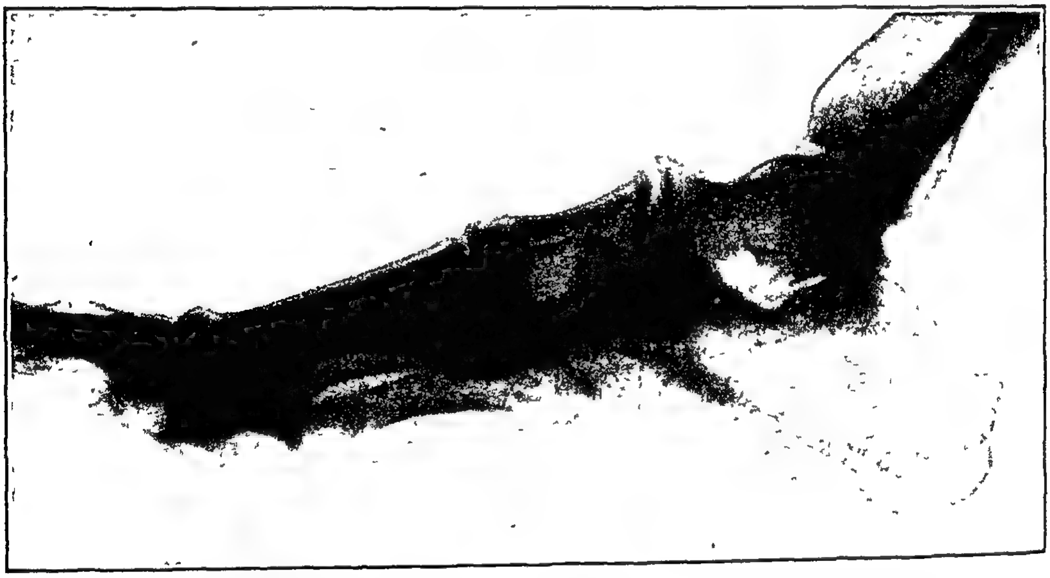


Fig. 222.—Traumatic arthritis with crow-beaking at the astragalo-scaphoid joint. Note the absence of a joint between the scaphoid and cuneiform I and the absence of a calcaneo-cuboid joint.

Phemister has stated that the fate of the traumatized head of the femur is determined by the extent of destruction of its principal blood supply. The surface of the head of the femur is largely articular; the same is true of the surface of the astragalus.

According to Watson-Jones the astragalus has four points of entry for its blood supply: (1) dorsal surface of the neck; (2) interosseous ligaments in the sinus tarsi; (3) internal surface; (4) through the trigonum.

In the treatment of fractures of the astragalus, Miller attempts a closed manipulation to effect accurate reduction to enhance restoration of circulation to the body of the bone If necessary, to obtain accurate apposition of fragments, he performs an open reduction

In the presence of a severely traumatized astragalus, the burden of the hour is to decide how to get the best functioning foot out of the situation without indefinite delay All students of this subject are in general agreement that following the severely fractured astragalus without intervention there will surely ensue, first, aseptic necrosis of the body of the bone and, later, degenerative changes involving the adjacent joints

Fig 223 —Fracture of the astragalus

Miller proposes the following procedure

Given a severely injured or fractured astragalus, reduce it as early and accurately as possible

Six to eight weeks later do a subastragalar arthrodesis and carry the member through convalescence from this surgery

If after removal of the plaster cast, protection and reasonable use of the member, the ankle joint appears to be disorganized or is unduly uncomfortable, fuse that joint promptly Do not do an astragalectomy except in the presence of sepsis or hopeless comminution of the body of

the astragalus. If astragalectomy is elected, the patient and the surgeon should anticipate a later operation for fusing the tibiofibular mortise astride the os calcis. Miller emphasizes the fact that astragalectomy in the adult foot gives a poor member for any exacting demands. Fusion of the malleoli to the os calcis gives an excellent result.

Pan-fusion of the ankle is not advised as a primary measure.

FRACTURE OF THE NECK OF THE ASTRAGALUS

Campbell considers fracture of the neck of the astragalus analogous to fracture of the neck of the femur, because the astragalus receives most of its blood supply from a branch of the dorsalis pedis artery which, like the artery supplying most of the blood to the neck of the femur, enters the lateral aspect of the neck. Following a fracture proximal to the dorsalis pedis artery, the blood supply to the body of the astragalus is impaired or inadequate, being derived only from very small branches entering at the ligamentous and capsular attachments. Anatomical reduction and adequate fixation are essential for revascularization. Unless revascularization occurs, the body of the astragalus may disintegrate and eventually become absorbed as an aseptic sequestrum. After fracture at the extreme distal end of the neck of the astragalus, *i. e.*, distal to the nutrient vessel, less marked avascularity and aseptic sequestration may occur with consequent irregularity of the articular surface and permanent traumatic arthritis of the astragaloscaphoid joint.

FRACTURE AND FRACTURE-DISLOCATION OF THE ASTRAGALUS (TALUS)

Traumatic arthritis of the tibio-astragalar joint is a frequent complication of injuries of the astragalus. Compression injuries producing fracture-dislocations of the astragalus exert sufficient force upon the chondral surface of the tibia and the dome of the astragalus to produce impacted fractures or infractions of these cartilage surfaces. Traumatic arthritis of the tibio-astragalar joint is produced as much by the initial injury as by the pathologic change subsequent to inadequate nutrition of the astragalus itself. The degree of pain and disability from this traumatic arthritis is the determining factor in deciding whether or not tibio-astragalar fusion should be done. The blood supply to the astragalus is relatively poor, and transcervical fractures interrupt this blood supply.

Revascularization after injury of the astragalus is slow, hence there is a high incidence of aseptic necrosis of varying degree, noticeable particularly in the body of the bone.

Inversion of the foot does not force the astragalus medially—it tilts it

Meekison emphasizes the value of active movements while the patient's ankle is in plaster Movements of the knee and toes are of the utmost importance as far as the end results are concerned Patients should exercise five minutes every hour Get the individual back to industry or to his place in society in the quickest possible time

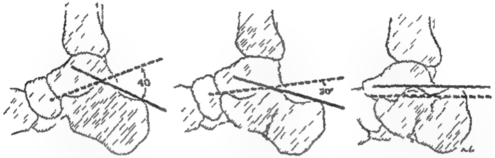


FIG 224 —Normal tuber-joint angle as described by Bohler *A* The normal tuber joint angle is the criterion for the correction of deformity This consists of the angle formed by the line connecting the upper surface of the tuberosity with a line through the subastragalar joint and ranging from 22 to 30 degrees In comminuted fractures either this angle becomes smaller or disappears entirely or the tuberosity may even be raised above the joint surface In treatment Bohler recommends that the tuber-joint angle be overcorrected to 35 or 40 degrees *B* Tuber joint angle of 20 degrees in a mild fracture of the os calcis The longitudinal axis of the astragalus approaches the horizontal *C* Tuber-joint angle zero in a severe fracture of the os calcis The tuberosity is displaced upward so far that the tuberosity line stands higher than the joint line The longitudinal axis of the astragalus is almost horizontal (Redrawn from Reich courtesy of Jour Am Med Assn)

FRACTURE OF THE OS CALCIS

The most frequent cause of fracture of the os calcis is a fall from a height, such as the fall of a railroad brakeman from a box car, a fall in an elevator shaft, or a fall in an elevator which suddenly strikes bottom

The two main groups of fractures of the calcaneum are (1) fractures due to tearing of the Achilles tendon, and (2) fractures due to crushing The gravity of these fractures depends on the extent to which the compact upper articular surface is driven into the spongy substance of the bone Lenormant divides these fractures into three groups, the first not being susceptible to surgical treatment, the two others justifying surgical intervention

Lenormant emphasized the importance of the structure of the calcaneum which consists of spongy bone reinforced by three kinds of trabeculæ, the posterior extending downward and anteroposteriorly, the anterior, extending in the reverse direction, and the third group combining the two others Between these trabeculæ, the spongy tissue is soft and friable In fractures due to crushing, the thalamus, or the compact articular surface, is driven into the cavity below, be-

tween the bony trabeculæ. The extent to which the upper articular surface is driven in is indicated by the angle of the tuberosity. The crushing of the thalamus causes a deviation of the articular surface of the astragalus, which is forced downward and backward.

The symptoms are pain, inability to bear weight, tenderness, and deformity. The roentgenogram frequently shows the fracture to be comminuted (squash fracture).

Conn presented the following recommendations for the management of a common fracture of serious consequence.

1. Avulsion fractures of the tuberosity are best treated without a tenotomy of the tendon Achilles but by metallic internal fixation with the foot immobilized in a position of mild equinus.

2. Simple linear fractures of the tuberosity which do not extend into the subastragalar joint are at the worst only a minor problem and need only simple immobilization The presence of pain on lateral motion despite an apparently negative roentgenogram should however be regarded with the utmost suspicion and if in doubt a surgical inspection of the subastragalar joint is justified.

3. If radiating fracture lines traverse the subastragalar joint producing irregularity a fusion is mandatory. In the absence of serious contiguous bony malformation the mortise graft of Gallie is the operation of choice.

4. The squash or eversion type of fracture of the os calcis present a disorganization of the subastragalar joint with a depression of the sustentaculum tali and a malalignment of the astragaloscaphoid and calcaneocuboid joints. If not fully reduced constant severe strain on the plantar ligaments results The tuber angle represents the only satisfactory measure of deformity and reduction. If the angle is straightened or inverted by the initial violence, anatomical reduction will be impossible in 90 per cent of the cases. The treatment should consist of a two-stage operation, the first, disimpaction and lateral compression of the tuberosity to be followed immediately by pin traction with the force so exerted that the tuberosity will be extended backward and downward. Following healing of the fracture lines in the best position obtainable, a firm bony arthrodesis should be induced of the subastragalar, the astragaloscaphoid, and the calcaneocuboid joints. Care should be taken to see that these fusions occur in a position of very slight inversion of the tuberosity and a moderate degree of flattening of the longitudinal arch.

5. Old squash lesions are best treated by triple arthrodesis.

6. A resection of the sural nerve is an imperative part of every triple arthrodesis.

7. A synchronous fusion of the subastragalar and the transverse tarsal joints does not represent an especially difficult or intricate

procedure, nor is it radical when the lost motion in the untreated case is weighed against compensatory mobility which develops in the surgically fused foot

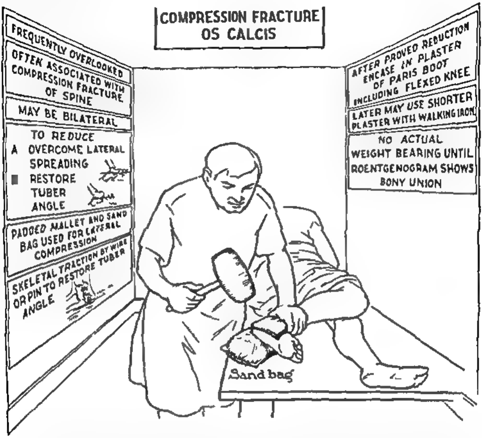


FIG 225 —Compression fracture of the os calcis Correction of the broadening of the bone and of the changed salient angle are essential in reduction of compression fractures of the os calcis Forceful lateral compression with hands or a padded mallet used with foot placed on its side on a suitable surface is followed by traction through the insertion *of the tendo achillis or calcaneus itself After reduction the foot is held in a plaster-of* Paris boot snugly applied Weight-bearing on the foot is deferred until the bone has healed (Scientific Exhibits Am Med Assn Convention 1942)

Deformity —In fracture of the os calcis, deformity often consists of a greatly flattened arch The prognosis for relief of symptoms through treatment of the bone deformity is not very favorable The mechanical disarrangement of the fragments produces the following obstructions to function

1 The posterior fragment is pulled upward and everted, thus flattening the arch of the foot

2 Callus formation and protrusion of the anterior end of the posterior fragment create a prominence behind and beneath the external malleolus interfering with the motion of rotation and producing painful impingement of the bone and tendons

3 The astragalocalcaneal joint is greatly disturbed in its equilibrium

and smoothness of function so necessary for weight-bearing. The roughening of the articular surface causes a painful arthritis so that the person complains of pain when stepping on unlevel ground and limps because of the pain and ankylosis within the joint.

Tuber-joint Angle.—Böhler calls attention to the normal 22 to 30 degree angle formed by a line extending through the upper surface of the tuberosity and another drawn through the subastragalar joint. In comminuted fractures, this angle becomes smaller and may even disappear. The tuber-joint angle should be overcorrected to 35 or 40 degrees. (See Fig. 224.)

In a large percentage of fractures of the os calcis, pain and disability persist even though efficient treatment was carried out at the time of the injury. They are particularly apt to persist if the patient's occupation necessitates walking over rough ground. As a rule, disability arises from incongruity of the subastragalar joint, with consequent traumatic arthritis. Excessive bone formation may be present below and behind the external malleolus. If the lateral deviation or eversion of the os calcis is pronounced, there is a tendency toward valgus deformity and foot strain.

With a few exceptions, a fair trial of weight-bearing, aided by arch supports should precede operative treatment.

Fractures of the os calcis with little or no displacement or broadening of the lateral dimension of the bone are treated by immobilization of the foot in a cast for a period of four weeks, and thereafter in a walking cast. For those with displacement, angulation, eversion, or broadening of the os calcis, the Böhler method of treatment is recommended. Following any form of conservative treatment, even when it restores relatively anatomical alignment, some patients continue to complain of pain and rigidity of the foot.

In severe "squash" fractures in which the tuberosity was everted and compressed and the sustentaculum tali depressed and fractured, Conn observed a disruption of the calcaneo-cuboid-astragalar junction, with subluxation of the calcaneo-cuboid and astragalo-scaphoid joints. Of 39 "squash" fractures of the os calcis treated by subastragalar arthrodesis, the results were unsatisfactory in one-third of those which were fresh fractures and in over one-half of those which were treated late. In 5 cases treated by the Böhler method, subsequent lateral motion was limited and painful.

Harding uses a sharp claw retractor forced through the skin at the back of the heel. He never finds it necessary to cut the Achilles tendon. A cabinet-maker's D clamp is applied to the sides of the os calcis, the pressure points being protected with felt or rubber. The compression is slowly continued until the width is the same as that of the other heel, when plaster is applied.

Cotton's rules for the treatment of fractures of the os calcis are as follows (1) Loosen up the fracture by manipulation (2) Pull down the heel, using ice tongs (3) Free the joint motion between the astragalus and the os calcis (4) Push the displaced bone under the malleolus This is done by the use of a mallet on the outer side of the foot, which is protected by a piece of felt The inner side of the foot is supported on a sandbag (5) Apply a plaster-of-Paris cast with the Achilles tendon relaxed

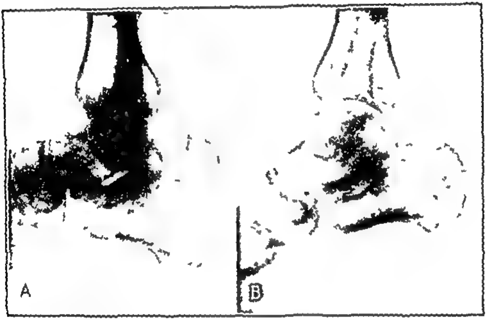


Fig 226 —*A* Avulsion of a large section of the os calcis by the tendo achilles due to violent contraction of the gastrocnemius muscle *B* illustrates complete replacement and consolidation Note In these cases the Achilles tendon should be lengthened

Magnuson advises tenotomy of the Achilles tendon followed by replacement of the posterior fragment If the fragment is impacted, the foot is placed over an orthopedic block and the impaction broken up After the fragment has been reduced the foot is placed in strong inversion and put in a cast that is molded well under the longitudinal arch

The procedure of Funsten and Hall is as follows (1) Operation is delayed for from four to eight days (2) Open lengthening of the tendon of Achilles is done by the sliding method (3) The impaction is broken up and the displacement of the posterior fragment reduced by the use of a No 24 catheter passed over the os calcis With the patient lying prone, counterpressure in the arch is obtained with a padded wooden board wrapped in sterile dressings and maintained against the surgeon's chest (4) The inner edge of the foot is placed against the sandbag, and the fragments under the outer malleolus are impacted

with a mallet and roller bandage. (5) A plaster cast is applied to hold the foot in slight inversion at a 50-degree angle.

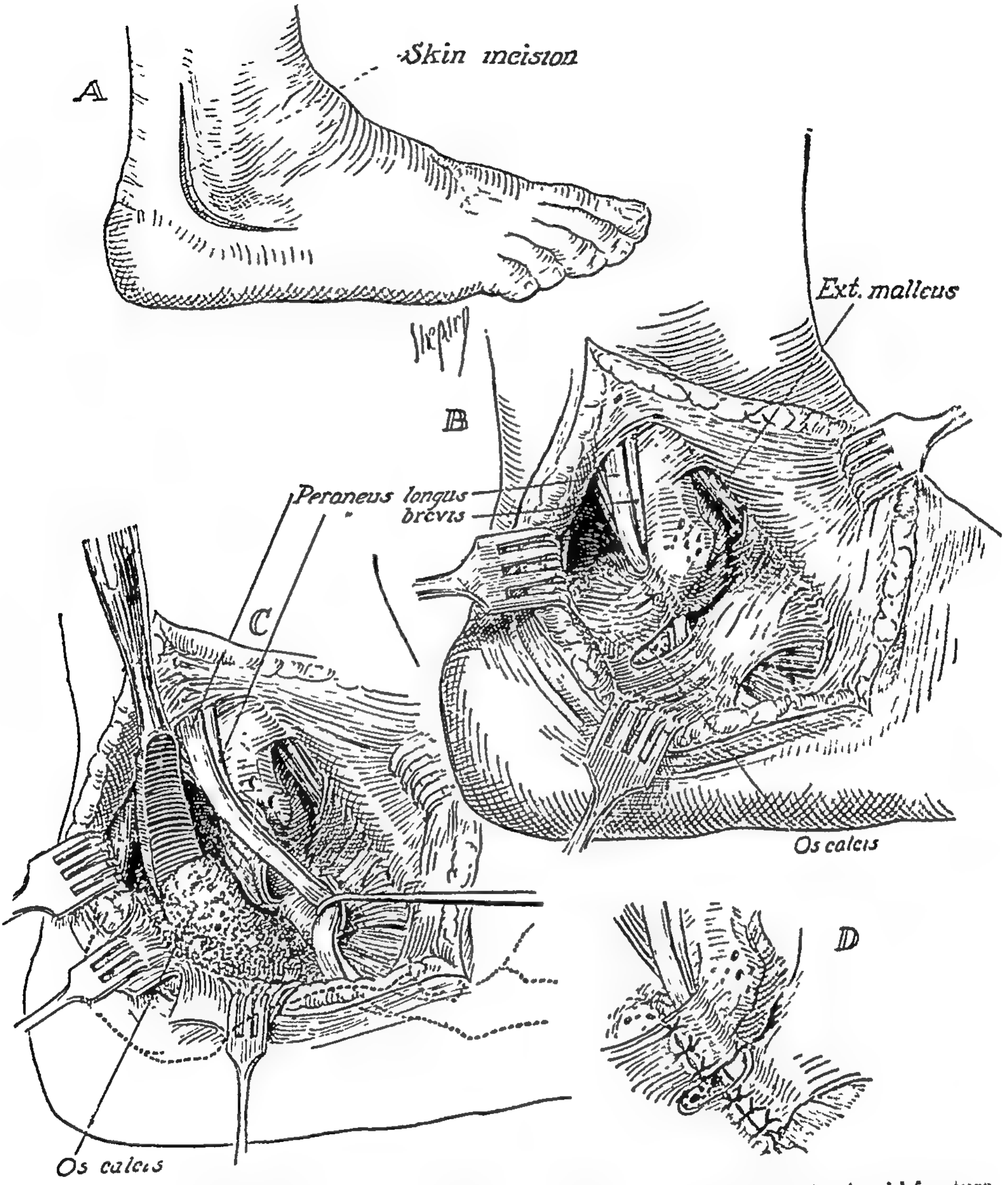


FIG 227.—Drawing showing Magnuson's method for relief of disability in old fracture of os calcis A, Line of incision B, Excess callus formation under arrow; displaced tendon pinched between external malleolus and callus. C, Method of removal of callus with sharp curved chisel (no curetting). D, Replaced tendons of peronei longus and brevis back of the malleolus. Cruciate ligament sutured over tendon. (Magnuson, Fractures, courtesy of J. B. Lippincott Company)

The prognosis in fractures of the os calcis is poor, partly because the bone is spongy and does not heal readily. Unless the fracture is reduced, the patient is usually disabled for a long time and suffers pain in the foot on weight-bearing. The most serious cause of disability

is traumatic arthritis at the subastragalar joint, the treatment of which is arthrodesis as proposed by Reich, Conn, and Wilson In fracture of os calcis treated by compression clamps there is danger of necrosis of skin, infection of soft tissues, and osteomyelitis

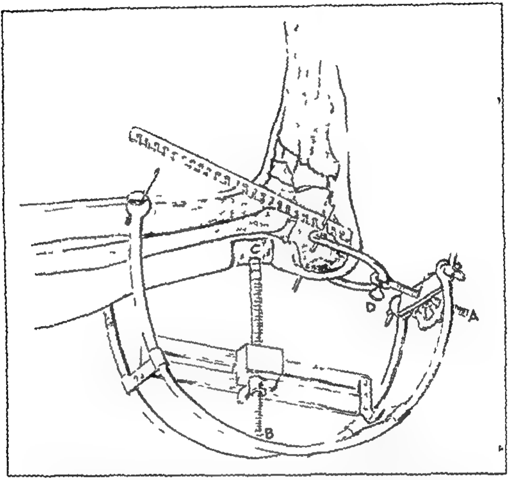


FIG 228—Sketch of Conn's traction apparatus for reduction of the upward displacement and the foreshortening of the tuberosity of the os calcis Positions of the transfixion pins are shown also the slotted metal strips two of which are incorporated in the plaster cast to fix the extension *A* indicates the extension mechanism, *B* the elevating screw and *C* the heel rest *D* indicates the sliding arc permitting control of the position of the heel (Conn courtesy of Jour Indust Hygiene)

Fracture of the os calcis is one of the seriously disabling injuries The heel is subjected to severe stress and strain The person with a painful heel finds it difficult to stand and walk, and do heavy labor

In cases of comminuted fracture of the heel including the subastragalar joint, Pridie advises total excision of the os calcis

When such fractures heal, the result is usually subastragalar arthritis with persistent pain and stiffness Removal of the os calcis eliminates pain, provides a wide range of inversion and eversion, mobility of the whole foot and good toe action

Causes of unsatisfactory end results are listed by Eastwood as follows:

In addition to arthritis of the subastragalar joint, failure has also been ascribed to the following causes:

1. Loss of the normal arch.
2. Spur formation.
3. Outward deviation of the heel, with static flat-foot.
4. Simple flat-foot, from weakness of ligaments.
5. Pain due to pressure from the presence of excess of bone below the external malleolus.
6. Fibrosis of tendons and joints of the foot.
7. Alteration in the structure of the affected bone.

Every effort should be made to coöperate with the surgeon in finding suitable employment and a gradual return to full work before the patient become "compensation-minded."

In a review of 47 cases of fracture of the os calcis, comprising 53 separate fractures, most of which were treated by simple immobilization without an attempt at reduction of the deformity, Eastwood found that 80 per cent returned to their pre-accident work. Although the majority did not complain of any discomfort, several patients stated that the injured foot was painful after a hard day's work or in wet weather.

Conn advises preliminary manual reduction and skeletal traction followed after five weeks by triple arthrodesis. The surgical procedure is the resection of a sufficient amount of bone from the subastragalar joint to correct the abnormal weight-bearing alignment, followed by arthrodesis. In the presence of an associated traumatic arthritis of the mid-tarsal joints, a triple arthrodesis is advisable.

Simon and Stulz describe fractures that include the thalamus, the thickest portion of the superior calcaneal cortex supporting the posterior articulating surface. In fractures of this type direct leverage must be exerted on the depressed and tilted thalamus to reëstablish its normal articular relations with the astragalus.

Lenormant discusses the treatment of these fractures. For many years a "let alone" policy was usually pursued, but the results were poor. Surgical treatment then began to be considered. The first operation resorted to was astragalo-calcaneal arthrodesis (Van Stockum). Other surgeons performed astragalectomy (Leriche and Tanton). Leriche keeps the articular surface in place with the aid of the metal devices of osteosynthesis (Dujarier's clasps or Lambotte's clamps).

The method of Lenormant and Wilmoth consists in reducing the fracture by careful adjustment of the fragments and by keeping the thalamus in place with the aid of bone grafts taken at first from the ex-

ternal malleolus and later from the internal aspect of the tibia The foot is immobilized by means of sacks of sand and, after the skin sutures have been removed, the foot and leg are put in a plaster cast The cavity below the thalamus is obliterated by these grafts The results shown by Lenormant were remarkable The calcaneum is well reconstructed The articular deviation is minimal Certain cases,

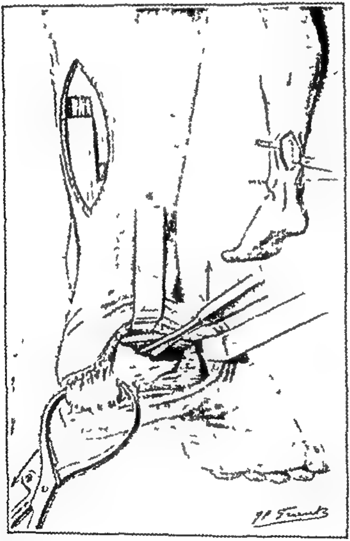


Fig 229 – Subthalamic fracture of os calcis (Sicard and Mutricy courtesy of Jour de Chir Masson et Cie)

however present ankylosis of the calcaneo-astragaloid and the calcaneo-cuboid articulations, without functional impairment The grafts are well tolerated

For subthalamic fractures, Lenormant and Wilmoth recommend the insertion of osteoperiosteal grafts Gallie prefers a bone graft across the subastragalar joint

French-Heel Fractures of the Tarsal Scaphoid.—These are sprain fractures of the superior surface of the tarsal scaphoid affecting the anterior capsular ligament of the ankle joint, the superior astragalo-scaphoid, and the dorsal scaphoid cuneiform ligaments. Occasionally, a small fragment of bone is detached from the anterior portion of the superior surface of the astragalus or the posterior portion of the superior aspect of the cuneiform bones. The size of the fragment varies from that of a pea to half that of a cherry. According to Wright, the mechanism is usually hyperextension (plantar flexion) of the foot on the ankle joint accompanied by inversion or eversion. Fractures of this type

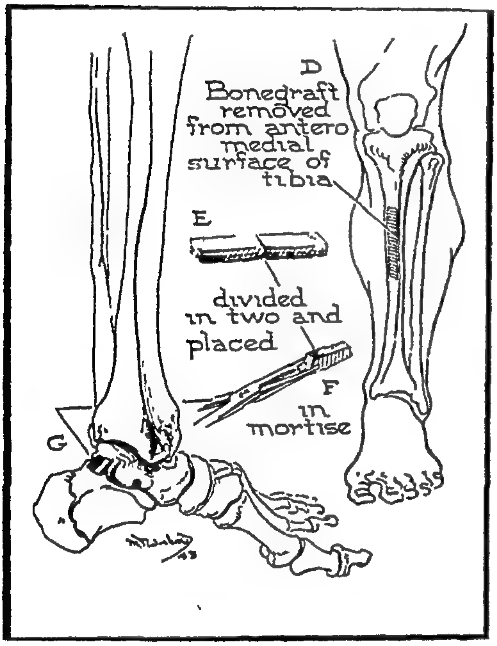


Fig. 230

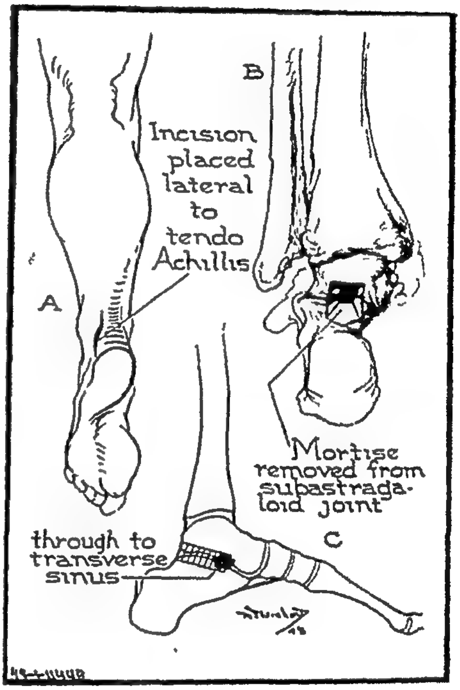


Fig. 231

Fig. 230.—Removal of tibial bone graft for Gallie's subastragalar arthrodesis. (Conn, Courtesy of Jour Bone & Joint Surg)

Fig. 231 —Successive steps in Gallie's mortise bone graft of subastragalar joint. (Conn, Courtesy of Jour. Bone & Joint Surg)

occur most often in females, wearing high-heeled open slippers or pumps, who invert and hyperextend the foot in an accident such as falling on stairs. Most of them are diagnosed as sprains. They are best treated by flexion of the foot maintained by anterior "stirrup" adhesive straps and the temporary wearing of low-heeled shoes and an ankle support.

Fractures of the Cuboid Bone.—Although the cuboid is well protected laterally by the base of the fifth metatarsal bone, it may be fractured by a crushing injury such as may occur when a wagon wheel passes over the foot. The treatment includes the application of a plaster cast to hold the foot in neutral position for two or three weeks, and then, the wearing of a high-laced shoe which contains a felt pad to

cause slight eversion and is built up $\frac{3}{16}$ inch on the outer border of the heel and sole Radiant heat, massage, and active motions are recommended

FIG 232 —Fracture of os calcis

Fractures of the Cuneiform Bones —Fractures of the cuneiform bones are rare because of their protected position They are due usually to a crushing injury produced by a wagon wheel, a fall, or the impact of a heavy falling object The treatment is similar to that for fracture of the cuboid bone, except that a felt pad is placed under the longitudinal arch and the inner border of the shoe is elevated

Fig. 233.—Fracture of os calcis with osteomyelitis.

Fig. 234.—Fracture of os calcis involving subastragalar joint.

FRACTURES OF THE METATARSAL BONES

Fractures of the metatarsal bones are due to indirect trauma They may be produced by running, jumping, dancing, or any other violent muscular effort involving the feet As the initial trauma is often very slight, it may be unnoticed unless roentgenograms are taken The fractures may be transverse, spiral, or linear As a rule, elastic traction combined with a banjo splint will effect a reduction If this is not successful, open operation with the use of a pry-pin and the application of plaster to maintain the reduction are advisable

In molding the plaster, the longitudinal and transverse arches must be maintained or restored

Following fracture of the metatarsal bones, it is important to carry out physiological treatment with proper shoes, resilient metatarsal and longitudinal arch supports, transverse arch exercises, massage, and contrast sprays

In fractures of the metatarsal bones surgery is indicated when manual reduction is unsuccessful or maintenance of reduction is impossible

Campbell's Technic—A longitudinal incision is made over the fracture site After exposure of the fracture, reduction is accomplished by angulation and approximation of the bones Reduction is maintained by one of the following methods of fixation (1) drilling the fragments, inserting a rustless steel wire loop, and twisting the ends of the wire together, or (2) inserting an autogenous bone peg of appropriate size into the medullary cavity of the proximal fragment and leaving a small protruding portion to be placed into the medullary cavity of the distal fragment, as reduction is effected by angulation

The chief object of the operation being to prevent the formation of an osseous mass on the sole of the foot and flexion contracture or claw-toes, which cause pain on weight-bearing, care is taken to prevent plantar bowing at the fracture site

A cast which holds the toes and forefoot in plantar flexion is applied and left on for three or four weeks The foot is then placed in a walking cast with a felt pad beneath the line of fracture to maintain plantar flexion, and the patient is allowed to resume walking gradually, with the aid of crutches Support is worn until complete osseous union is demonstrated by the roentgenogram Physical therapy and active exercises with a toe board will reduce the period of convalescence

Fracture of the Metatarsal Bones Simulating Thrombo-angutis Obliterans—A case of fracture of the shaft of the second, third, and fourth metatarsal bones is reported by Lapidus There was evidence of mechanical impairment of circulation in the second and third arteriæ metatarsæ dorsales and plantares with lack of blood supply and gangrene of the third toe The clinical picture closely resembled that in thrombo-angutis obliterans

MARCH FOOT

March foot, sometimes called "Deutschländer's disease," occurs in the shafts of the metatarsals and the surrounding soft parts. It develops insidiously with slowly increasing pain which at first arises after prolonged excessive effort, later after ordinary exercise, and ultimately becomes continuous and incapacitating. It is like atrophic osteoporosis.

Frequently the swelling of the forefoot is associated with an insidious spontaneous fracture of one of the metatarsal bones. According to Speed and Blake, the condition has been recognized for many years, especially by foreign military surgeons who encountered it in their troops after strenuous duties or long marches.

The history and clinical appearance are typical. A soldier after a long march, or a civilian who has been subjected to excessive foot strain, complains of pain in the forefoot and tenderness over the anterior portion of the second or third metatarsal bones. As this is not sufficient to disable him, he continues with his duties, only to have the disability increase. After a few days a swelling is noticed on the dorsal surface of the forefoot.

Dodd believes that march foot is an auto-traumatic complication of subacute flat-foot occurring in architecturally weak feet. Muscular spasm and fatigue alternate, and as the latter supervenes, gradual stretching of the ligaments permits direct trauma to the bony skeleton of the foot. The shocks affect the slender, resilient metatarsal bones. Most commonly affected is the second metatarsal, and next most frequently the third. The majority of cases occur in soldiers carrying full packs on active service, but civilians engaged in similar heavy occupations are also affected. Women with arduous standing and weight-carrying work (waitresses, shop assistants, and nurses) may develop the condition. Narvi believes that overloading causes stasis and thrombosis in the soft parts surrounding the bone, thereby interfering with the nutrition of the periosteum.

The roentgenograms of the metatarsal bones reveal a fracture line. In several cases, Speed and Blake found the normal sequence of changes shown by the roentgenograms are as follows:

1. If the roentgenograms are taken very soon after the onset of symptoms, the bones are found to be entirely normal and only swelling of soft tissues is noted.

2. After from one to three weeks, there is a little periosteal fuzziness at the site of the beginning fracture, and very close observation may reveal a minute line of fracture. Occasionally the fracture appears before the periosteal reaction is seen.

3. A little later the periosteal shadow becomes more distinct and

circumscribed, and it is noted that this callus is overabundant for the size of the bone involved and the size of the fracture

4 Next, the fracture shows signs of union, and the callus is more dense and well circumscribed into a spindle shape

5 Six months later, solid union with absorption of the excess callus is found

According to Speed and Blake, rest, hot applications, and relief from weight-bearing may arrest the condition during the stage of preliminary swelling, and restore the foot to normal after a week or ten days Toe exercises to restore the flexibility of the anterior metatarsal arch and a proper arch support or strapping of the forefoot should be employed when walking is resumed The average disability is from four to eight weeks

The treatment recommended by Dodd consists of rest in bed until the pain and edema subside and complete immobilization of the foot or feet by plaster, which is applied to maintain a dorsiflexed and an inverted position, with a well-molded arch If necessary, manipulation of the feet into this over-corrected position under anesthesia is advisable The foot-wear is adjusted with inside wedges to the heel and sole and metatarsal bars or crescents

March Fracture or Insufficiency Fracture —The pathological disorder being essentially one of local inadequacy of metabolism, causes skeletal changes which render the bone more pliable

Nickerson who studied more than one hundred cases suggests the term "insufficiency fracture" Those cases which exhibited early periosteal proliferation did not fracture, those which did not exhibit early periosteal proliferation fractured, probably due to the absence of this periosteal buttress Those that did fracture always demonstrated displacement of the distal fragment laterally, indicating the presence of a definite force in a constant direction He believes that that insufficiency fracture is, in its early stages, a pseudofracture, which should be included in the same group as those caused by other nutritional states

A plea is made for earlier diagnosis, *i e*, before fracture has occurred

Hartley used the term "fatigue fractures of bone" Scott subdivides the various causes of march fracture in the following manner

I Predisposing causes, *local*

1 Morton's syndrome
2 Inflammatory changes
3 Vasospasm leading to bone atrophy
4 Shoe gear irritation
5 Decreased dorsiflexion of foot
6 Muscle fatigue
7 Spasm of intrinsic muscles
8 Functionally weak foot

II. Predisposing causes, *systemic:*
   1. Bacterial.
   2. Neurologic disturbances.
   3. Rheumatic diathesis.
   4. Nutritional deficiencies.
   5. Polyhypovitaminosis.
   6. Mild hypothyroid state.

III. Precipitating cause:

This is generally agreed upon to be marching; or according to Brandt, the result of "rhythmically repeated subthreshold mechanical insults acting by summation to a point beyond the capacity of the bone to bear stress."

One should differentiate between inflammatory and reparative types of swelling. This can be done very easily by what Scott's patients call the "pinch test." By pinching the skin (over the second or third metatarsal heads) between the thumb and index finger on both the normal and affected feet, a thickening or turgidity in the subcutaneous tissue will be noted if inflammatory edema is present. In most cases this test will become negative at the end of the third, fourth, or fifth day. Bed rest is continued for 2 days after the pinch test is negative.

Scott reported 58 cases of march fracture of which 48 were studied from the standpoint of basal metabolic rate. The average rate was minus 10.72 per cent. The average pulse rate was 62 and 57 per cent of the men were either tall or fat.

Bed rest for a period of five days and the administration of desiccated thyroid (1 grain three times a day) for a total of nineteen days was the routine treatment followed.

Mild, non-disabling symptoms were complained of in half of the patients thus treated.

Those who received thyroid showed better intermediate results than those who were treated by bed rest alone.

The final results were excellent, except in that group having complete fractures.

It is probable that a mild hypothyroid state may be a predisposing systemic cause in patients who develop march fractures. Cast treatment is not necessary, nor is it indicated except possibly in those cases in which the fracture line is complete. Bed rest continued through the period in which the inflammatory swelling is disappearing and continued for two days thereafter, is Scott's treatment of choice. The administration of thyroid substance for a short period is apparently helpful.

In World War II the syndrome known as march fracture once again became much in evidence. It first gained prominence during World War I, but the condition had been discussed by several authors during

the latter half of the 19th century and Breithaupt, a Prussian Military Surgeon, described it as early as 1855

The incidence of march fracture in World War II was higher than recorded cases would indicate, due to the fact that many cases are missed

The main factors in etiology appear to Wilson to be as follows (a) a poorly developed recruit with poor muscle tone, (b) an unduly high ratio of weight of load carried to body-weight, (c) a tendency to atavism of the foot, (d) prolonged and repeated foot strain, (e) change to the army boot

Ambulatory treatment should in all cases be instituted early Its main advantages are an early return to full duty, completely satisfactory healing and ultimate foot function, the elimination of hospitalization and the continued uninterrupted application of most of the physical and military training

The possible prevention of the condition of march fracture appears to lie in the attention in early youth to the proper physical development of the body and in particular early athletic training including special exercises to develop and strengthen the foot An adequate diet rich in vitamins and minerals is of paramount importance The tempo and duration of the recruit's training should be regulated according to his physical standard

Sufficient time should be allowed for the recruit to accustom himself to the transition from civilian to army foot-wear Accurate shoe fitting at the outset is essential

In all cases of pain in the foot following prolonged strain, such as marching, the possibility of march fracture should be borne in mind The diagnosis seldom presents any difficulty, the history and clinical signs being so characteristic Radiology may at first show nothing and should be repeated in all doubtful cases after two weeks

There are many predisposing factors in march fractures, some of which may be controlled

Initial roentgenographic examination is often negative and should be repeated In 8 5 per cent of Leavitt and Woodward's 47 patients, no fracture line was visible at any time to accompany callus formation

Early diagnosis and treatment by absolute freedom from weight-bearing until soreness disappears, gives the best results

Leavitt and Woodward s end results have been poor They conclude that march fracture in soldiers is more serious than other reports have indicated

Dew and Wooten reviewed fifty-eight march fractures in fifty-five trainees Fifty-three of these successfully completed the course of training in a replacement training center with physical activities which included marches up to twenty-five miles

Two cases had subsequent march fractures, the first one, and the second, two. The former successfully completed his course of training after recovering from the second fracture, and the latter was reclassified to limited service.

It is strongly advised that march fracture cases be treated as outpatients with the army shoe as a splint whenever possible.

Active coöperation of the line command with the medical officers in instituting simple prophylactic measures has greatly reduced the incidence of march fractures.

Bernstein and Stone regard a pair of good feet as one of the infantryman's greatest assets, since he may be called upon to make forced marches for long distances over rough terrain, during inclement weather, and under other adverse conditions.

During World War I, "march fracture" of the foot was also known as "pied force," "Deutschländer's disease," and "march foot." Today, this same condition is also called "fatigue fracture" or "stress fracture."

An early march fracture causes only mild discomfort, since some soldiers with march fracture frequently walk around with very little pain or disability, and never appear on sick call.

In a recent issue of the Military Surgeon an open letter to the Editor regarding Bush's article on march fractures states:

Trainees with march fracture recover completely, make good infantry soldiers, and finish all the required prolonged marches and speed hikes, as ably as the soldier who has not had a march fracture.

"May we in field units express an opinion? Most of these men do not make good infantry soldiers, once they have suffered such a fracture. Their ability to walk great distances is gone, because of the pain in the foot. The general impression from seeing a number of cases, before, during and after treatment for march fracture is that perhaps it would be a wise practice never to attempt to put one of these men back in the infantry."

Etiology.—This type of fracture is due to direct bone stress, following the complete fatigue and exhaustion of the supporting structures of the foot, which include the muscles, ligaments, and fascia. Bernstein and Stone do not agree with Berkman that a stiff-soled army shoe is a predisposing factor in the development of this fracture, since most of their cases occurred in soldiers between the fortieth and sixtieth day of their training, at which time the shoes are well "broken in." Long marches constitute a definite etiological factor.

Symptoms.—The soldier first notices pain in the involved foot during a long march or a "speed march." The pain is of a dull, aching, burning character, and is rarely severe enough to cause him to "fall out" of a hike. As the soldier continues to perform his various duties during the next few days or weeks, the pain gradually increases in intensity and severity, and a limp develops. The progression of this chain of events

continues with increased severity, until swelling of the dorsum of the foot becomes definitely noticeable, at which time the soldier usually appears on sick call. The first appearance may not occur for several days to several weeks after symptoms are noticed.

Physical Findings.—On examination, the patient walks with a definite limp on the involved side, primarily because of pain on weight-bearing. He walks with a rigid fore-foot held either inverted or everted, depending upon the metatarsal fractured. The dorsum of the foot is definitely swollen, the swelling is most pronounced at the fracture site and obliterates spaces normally seen between the extensor tendons. At times, there is a definite palpable increase in local heat. The most constant finding is localized tenderness at the fracture site. Crepitus is rarely elicited. Other signs frequently present are pain on forced plantar flexion or on traction on the corresponding toe.

FRACTURES OF THE FIFTH METATARSAL BONE

Fracture of the base of the fifth metatarsal is a common injury. It is due to a twist of the foot or squeezing of the foot between two objects while the body is thrust forward and the leg is twisted. It may be caused when the bone is run over by a wagon wheel or is stepped on.

Ballet dancers are subject to transverse or spiral fractures of the shaft or base of the fifth metatarsal, the mechanism of which is an inversion of the foot plus a twist. In addition to the treatment of the fracture, support of the transverse arch is necessary. If any degree of flat-foot is present, it should be treated. A metatarsal elastic cuff is often beneficial. The combination of a Thomas heel and the author's rubber metatarsal crescent is recommended.

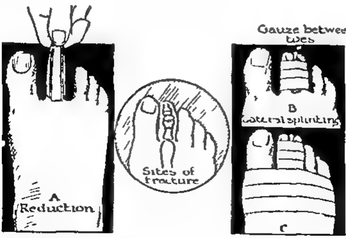


FIG. 235.—Treatment of fractures and dislocations of phalanges of the toes. *A*, Reduction carried out by placing four thin strips of adhesive plaster longitudinally on the affected toe as shown and pulling on ends of tape. Reduction is not often necessary. *B*, Lateral splinting to adjacent toe. Note gauze between splinted toes. *C*, Strapping indicated when greater stabilization is desired, as in fractures or dislocations of the proximal phalanx. (Courtesy of Johnson & Johnson.)

FRACTURES OF THE PHALANGES

Among the more important fractures of the phalanges are those which I have designated "bedroom fractures" of the toes and fractures of the great toe.

"Bedroom fractures" of the toes occur usually at night when one or more toes are stubbed against some article of furniture while the person walks around a dark room. They involve most frequently an unusually long second or fifth toe. If there is overriding, reduction followed by immobilization in plaster, with traction bands, is necessary. If reduction is unnecessary, adhesive strapping with a tongue depressor or hairpin splint is advisable. I have used a splint similar to the one I designed for baseball finger.

BARRACK'S FRACTURES

During World War II regimental surgeons saw many fractures of toes which occurred during sleeping hours and are analogous to bedroom fractures in civilian life.

FRACTURES OF THE GREAT TOE

Fractures of the great toe involving the metatarso-phalangeal joint are frequently followed by pain and limitation of motion, which prevents a graceful step. For such fractures, the use of traction and a banjo splint is recommended.

COMPOUND FRACTURES OF THE FOOT AND ANKLE

Among the most common causes of compound fractures are trauma sustained in industry, the action of explosives, and railroad, motor car, and truck accidents. Immobilization of fractured area at the earliest possible moment, *i. e.*, before the patient is moved, and the prompt administration of an adequate dose of morphine unless the patient is unconscious are most important.

It is imperative that débridement be carried out meticulously. The Orr treatment is recommended highly. Tetanus antitoxin should be given, and antitoxin against infection with the gas bacillus should be given in cases of severe crushing injuries.

In cases of metatarsal affections, the arch must be maintained whether the patient is ambulatory or not, because this frequently causes a painful, rigid gait, after the person is allowed on his feet

"Ten Commandments for the Treatment of Compound Fractures"*

1 Thou shalt handle the fractured extremity with the greatest care, splint and immobilize in an appropriate manner

2 Thou shalt make an emergency case of every compound fracture, giving it the earliest possible adequate treatment

3 Thou shalt scrub the parts involved with green soap and paint the wound's edges with a mild adequate antiseptic (it is preferable to use only soap and water)

4 Thou shalt recognize the fact that a large group of compound fractures can be cleaned up and closed, providing that, after careful débridement, strong antiseptics are not used which when applied, cause superficial devitalization of raw tissue surfaces

5 Thou shalt reduce, at the time of débridement, every compound fracture If immobilization cannot be relied upon by ordinary methods, vitallium screws, plates, and nails, efficiently used, maintain the approximation of fragments and seem to have a direct and favorable influence on the result and apparently in no way jeopardize the healing process

6 Thou shalt fill the wound with sulfanilamide crystals, whether it can be closed or not, for this substance seems to deter infection

7 Thou shalt immobilize the fracture in a plaster cast, fenestrated to give constant observation of the wound

8 Thou shalt use anti-tetanus serum combined with Perfringens Bacillus-Welch serum in prophylactic amounts, to be given as early as possible

9 Thou shalt use roentgen-ray therapy whenever possible during the first few days as a prophylactic against gas infection

10 Thou shalt, after the first week, use pectin therapy in those cases in which there is a loss of integument and a superficial wound, as it seems to stimulate the healing process and reduces prolific granulation and drainage

MALUNITED FRACTURES

Malunited fractures are those in which union has taken place with the fragments in an abnormal position The result is often an unsightly deformity sufficient to impair function by blocking a neighboring joint, uneven distribution of the weight or incongruity of joint surfaces, which interfere with proper balance or gait, and overriding of the fragments with considerable shortening

Campbell attributes malunion to (1) failure to secure accurate reduction, (2) faulty immobilization during the process of healing, or (3) failure to protect a recent fracture when consolidation is not yet complete Malunion can usually be prevented by efficient treatment of the fresh fracture In a small number of cases, however, it will occur despite the most skilful and thorough treatment

* James E M Thomson personal communication

CHAPTER XVIII

DISLOCATIONS OF THE FOOT AND ANKLE JOINTS

THE important dislocations of the foot involve the ankle, the astragalus, the scaphoid, the metatarsals, and the tarsal-metatarsal, metatarsal-phalangeal, and interphalangeal joints. Combined fracture and dislocation may occur.

FIG. 236.—Fracture of the first metatarsal neck producing a traumatic Morton syndrome.

As a rule, dislocations are easily reduced completely if the following routine is carried out:

1. Complete relaxation.
2. Increase deformity.
3. Reverse the force that produced the dislocation.

The dislocations that cause most trouble are:

1. Those that are not recognized.
2. Those that are almost completely reduced.

Advice:
1. Be liberal about anesthesia. 2. Anesthesia should be deep but short. 3. Remember the dictum:—EASY DOES IT.

DIASTASIS OF THE DISTAL TIBIOFIBULAR JOINT

Diastasis of the distal tibiofibular joint is associated with extensive ligamentous rupture and results from external rotation or abduction injuries at the ankle. Alldredge recently pointed out that it may occur without associated fracture but is more frequently seen in cases of Pott's fracture in which there is fracture of the internal malleolus or rupture of the internal lateral ligament together with fracture of the lower third of the fibula. Failure to recognize and treat the diastasis properly may result in permanent disability even when the associated fractures are accurately reduced.

The diagnosis of tibiofibular diastasis is based mainly on roentgenographic findings, although swelling and tenderness over the distal tibiofibular joint may be indicative when the fracture of the fibula is fairly high. Diagnostic roentgenographic signs of tibiofibular diastasis are: (1) The presence of an isolated fragment of bone between the distal tibia and fibula, resulting from ligamentous avulsion of the outer border of the tibia, (2) most cases in which there is a fracture 2 or 3 inches above the lower tip of the fibula associated with fracture of the internal malleolus or rupture of the internal lateral ligament, (3) widening of the space between the internal malleolus and the internal aspect of the astragalus when the internal malleolus is not fractured, (4) any deviation in the normal alignment of the external border of the astragalus with the external border of the tibia, (5) destruction of the parallel alignment of the lower tibia and superior border of the astragalus.

Gross diastasis of the mortise with marked widening between the tibia and fibula are usually recognized without difficulty. Apfelbach and Boim in 300 films of ankle fractures noted diastasis in 40 per cent at the time of injury, whereas widening of the mortise was observed in 94 per cent as a clinical end-result.

Accurate reduction of fractures about the ankle will prevent diastasis in most cases. Where accurate reduction is impossible because of the interposition of soft parts, open reduction is recommended by Alldredge. He advises the use of internal metal fixation if necessary. Whether internal fixation is used or not, the position in which the foot is immobilized after reduction is important. The position of choice for post-reduction immobilization is slight plantar flexion, eliminating any tendency for separation of the tibia and astragalus.

DISLOCATIONS OF THE ANKLE JOINT

Dislocation of the foot may be backward, forward, medial, or lateral. The first type is the most common. Dislocation of the ankle is generally caused by a twist of the foot with the superincumbent weight of the body coming down usually with a rotatory movement. As a rule it

can be replaced under gas or local anesthesia. Roentgenograms should always be made to exclude fracture of the tibia, since most malalignment about the ankle is due to fracture. A plaster cast should be applied and protected active motion undertaken after two weeks.

A backward fracture-dislocation of the ankle can be easily corrected if it is treated early. Meticulous care in the alignment of the bones comprising the ankle joint is imperative to prevent subsequent pain and disability. Massage, hot applications, and active and passive movements are essential. Care must be taken to guard against shortening of the Achilles tendon.

DISLOCATIONS OF THE BONES OF THE FOOT

Dislocations of the Astragalus.—Dislocations of the astragalus may be difficult to correct. If an attempt at reduction under complete anesthesia is unsuccessful, open operation is advisable. Sneed describes a case in which it was necessary to divide the peroneal tendons and remove the astragalus completely before it could be replaced. The foot was then inverted and the astragalus replaced in its normal relationship to the tibia, being held by an assistant while the foot was forced back into its normal position.

In this condition, I must emphasize the importance of perfect reduction in the restoration of ankle function and comfort.

Subastragalar Dislocation.—Subastragalar dislocation is rare. Panis reports a case of double dislocation of the astragalus. The mechanism of external subastragalar dislocation is strong pronation with eversion. The physical signs are eversion and abduction of the foot with prominence of the head of the astragalus on the inner side of the foot. In old cases, there is lowering of the malleoli with widening of the foot below the malleoli. Lengthening of the Achilles tendon facilitates reduction of a subastragalar external dislocation and permits easy lateral replacement of the dislocated os calcis. Traction of the os calcis should be accompanied by strong supination of the forefoot. When the astragalus slips into place easily, the feeling of crunching snow is noted. In old cases, astragalectomy or fusion may be indicated. In a compound fracture-dislocation, early astragalectomy should be considered if necrosis of the astragalus becomes evident in the roentgenogram.

A subtalus dislocation is described by Straus as one in which the talus remains in its normal position between the two malleoli, but all the other bones of the foot are dislocated in relation to the talus, but retain their normal relations to one another. Before such a dislocation can occur, it is necessary to have the navicular, cuboid and calcaneus freed from the talus. This requires great force. Such violence usually

results in fracture of the bones of the leg rather than in subtalus dislocation

Subastragalar dislocation is more common than the total number of cases reported would lead one to assume Shands in 1928 reviewed the literature, he found 138 cases and added one of his own, which was the first in the records of the Johns Hopkins Hospital Of 1,089 fractures of the ankle over a period of nine years, Stimson reported only five subastragalar dislocations over a similar period of time Straus in 1935 emphasized the infrequency of this lesion, stating that only 148 cases had been recorded in the 123 years since Judy and Dufaurest reported the first two cases in 1811

The types of dislocation may be described as inward, outward, backward, and forward The lateral displacement of the foot is usually associated with varying degrees of posterior or anterior displacement and may be classified as external and anterior, medial and posterior Therefore the seven cases reported by Hugh Smith were classified as medial, three cases, lateral, four cases

The functional relationship of the astragaloscaphoid and the astragalocalcaneal joints manifests itself in subastragalar dislocations, as there is an accompanying dislocation of the astragaloscaphoid joint

Complete relaxation is a prerequisite to successful closed manipulations Reduction may be accomplished by exaggerating the existing deformity, and then reversing the forces which produced the dislocation, with traction of the foot and direct pressure on the head of the astragalus The knee is flexed to relax the tendo Achillis A normal contour is restored with an audible snap

In a review of 535 dislocations, Smith found seven subastragalar dislocations, the incidence of occurrence being 1 3 per cent It was found that with prompt reduction good functional results could be anticipated No difference in end results was noted between the cases in which closed reduction was done and those in which reduction was obtained by open operation, although convalescence was somewhat prolonged in the latter cases Of the seven subastragalar dislocations, an excellent result was obtained in four, the end result in the other three cases is unknown

Associated fractures of the tarsal and metatarsal bones and of the tibia or fibula, which are common, may complicate treatment and produce permanent disability A permanent limitation of abduction and adduction of greater or lesser degree may be expected after violent trauma Old unreduced dislocations require complete tarsal reconstruction and arthrodesis

Dislocation of Tarsal Scaphoid Bone —Complete dislocation of the tarsal scaphoid is very uncommon Its infrequency is due to the secureness with which the scaphoid is held by ligaments, neighboring

bones, tendons, and muscles. This bone articulates with six bones, is firmly held by a series of interosseous dorsal and plantar ligaments, and is in close relation to the tibials, the extensor and flexor hallucis, the flexor digitorum, and the plantar muscles, the latter being reinforced by the strong plantar fascia.

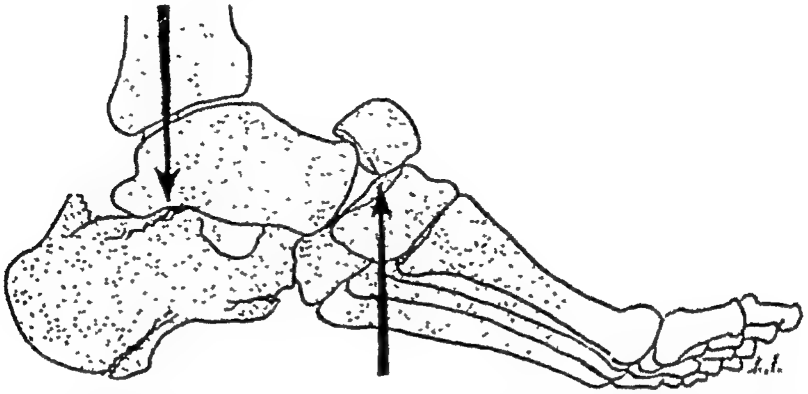


Fig. 237.—Dislocation of scaphoid bone associated with fracture of the os calcis. The bone was denuded of its articular surfaces and replaced with good functional result. (Adapted from roentgenogram, courtesy of McBride.)

Reduction of a dislocated tarsal scaphoid is very difficult, as tendons, shreds of ligaments, and joint capsule may be interposed between the bone and its socket, and the astragalus and cuneiform bones approach one another to close the gap left by the absent scaphoid. Moreover, with the tearing or separation of the inferior calcaneo-scaphoid ligament, the scaphoid tends to rotate on its horizontal axis. Consequently, in many of the cases reported, open operation for replacement or scaphoidectomy was necessary. Mock reported a case of complete dislocation which was reduced by closed manipulation.

An injury directly over the mid-dorsum of the foot is more likely to cause a fracture than a dislocation. However, if this trauma occurs in an oblique direction from within outward, as in a case of mine, the foot is plantar flexed, abducted, and pronated, the inner border forming a convex arc, and the chief strain occurs at the scaphoid articulations. Under such conditions the dorsal ligaments and the inferior calcaneo-scaphoid ligaments are torn, and the scaphoid escapes from its socket.

In a review of the literature, I found 26 cases of complete or nearly complete dislocation of the tarsal scaphoid.

Astragalo-scaphoid Dislocation.—Astragalo-scaphoid dislocation is due to severe wrenching of the foot in a fall from a height. The foot is swollen and fixed in either varus or valgus position. The head of the astragalus is tender and usually may be felt through the skin in its dislocated position. At its normal site, behind the scaphoid, there is

a depression Milch calls attention to the fact that the inner border of the foot, measured from the internal malleolus to the tip of the great toe, is shorter than the outer border, whereas the distance from the inner malleolus to the tip of the calcaneus remains unchanged These distances can be accurately measured with a caliper

The stereoroentgenogram will reveal the tibiotarsal, subtarsal, mediotarsal, or scaphoid dislocations *In early cases, closed reduction is usually possible In cases in which closed reduction is impossible,* open operation is advisable Simple reduction with suture of the torn ligaments, astragalectomy, or scaphoidectomy is recommended Astragalo-scaphoid dislocation with fracture of the scaphoid is rare *Dislocation of the major fragment of bone is more important than the* separation of a small fragment Reduction and suture of the scaphoid fragments is recommended

Dislocations of Metatarsal Bones —I have seen 1 case of complete *dislocation at every metatarsal base, in which reduction was effected* easily under ethylene anesthesia

Dislocations of Metatarsophalangeal Joints —Dislocations of the metatarsophalangeal joints are caused by injuries of various types, such as those produced by striking or tripping over a heavy object, crushing blows, end-on blows, twisting injuries, and falls *If seen early,* they are easily reducible, but if neglected, they usually require open operation Dislocations of the interphalangeal joints are treated similarly Local anesthesia works well in these cases Fusion may be necessary

CHAPTER XIX

INJURIES OTHER THAN FRACTURES AND DISLOCATIONS

SPRAINS AND STRAINS

Industrial—Occupational—Athletic Injuries

INJURIES OF THE FOOT AND ANKLE

The chief injuries are crush, leverage, contusion and concussion.

Treatment.—In the treatment of injuries, minutes are precious and time may determine the end result.

The important considerations are:

I. What to do.
II. When to do it.
III. What not to do.

The great divide:

Is the skin broken?
Is there infection?

The *Bones* most likely to cause residual disability are the:

Os calcis.
Astragalus, and the
Metatarsals, especially the first.

The *Joint* injuries are chiefly:

1. Ankle subluxation.
2. Subastragalar disruption.
3. Big toe metatarsophalangeal injury, and
4. Astragalo-scaphoid disturbance.

The painful jar caused by stepping on a cobblestone or a street car track usually localizes as a subastragalar sprain or strain.

Fractures, dislocations, combined fracture and dislocation, sprains, strains, and occupational, athletic, and military injuries of the foot and ankle are important because deformities and disabilities are reflected in carriage, posture, gait and comfort. Both acute and chronic conditions may be caused by direct injury, twists and crushing injuries of the foot, ankle, leg, and knee.

The industrial aspects of traumatic arthritis of the foot and ankle are very important.

After a fracture of the femur or tibia or an injury to the knee, a patient with an apparently excellent anatomical result may be unable

to stand or to walk because of pain in the foot and the ankle. Many excellent anatomical results are thus invalidated by residual foot and ankle troubles. One of the most serious types of arthritis in the foot involves the subastragalar joint, which controls lateral movement below the ankle. When this joint becomes the seat of arthritis as the result of injury, infection, or exposure, *subastragalar fusion* may be necessary.

Fracture of the os calcis is a common cause of arthritis of the foot.

Causalgia is a frequent complication or result of injuries to the nerves and blood-vessels of the foot, leg, and ankle.

In one year, *accidents in homes* in the United States accounted for 30,000 deaths and 170,000 severe crippling injuries. About one-half of the mishaps in homes are falls, and most of their victims are elderly persons. Carpets and rugs have a way of becoming misplaced or wrinkled, eyes may not be keen enough to see objects over which stumbling may occur, and muscles may fail to respond quickly enough to right the body in time to prevent disaster. Highly polished floors and poorly illuminated rooms, corridors, and stairways are also responsible for many injuries. A fracture may be sustained by falling out of bed. It would be a boon to many if beds were not over 1½ feet above the floor.

There is danger incident to standing on chairs or boxes. Even the household ladder may occasionally tip or slide. Many a crash has occurred because the housewife insisted upon carrying an armload of boxes up or down a stairway. The pile may be so high that the steps cannot be seen. Stair rails and floor covers are also sources of danger. If a small rug must be used on a highly polished floor at the top or bottom of a flight of stairs, it should be fixed in position with a few tacks. Bathroom hazards are numerous. Porcelain and tile tubs are slippery; a rubber mat on the bottom of the tub is an inexpensive safeguard. This mat should be sufficiently rough so that even "soapy" feet will not skid. There should be plenty of handles that can be grasped, especially by older people, in getting into or out of the bathtub. A bathtub with a side door has been invented.

THE TREATMENT OF INJURIES TO THE JOINTS OF THE FOOT AND ANKLE

The treatment of injuries to joints includes supportive and stimulative measures. Local treatment includes support, retention, massage, radiant heat, diathermy and inductotherm, galvanism, hydrotherapy, the whirlpool bath and the hot paraffin bath.

Injuries of even moderate severity are accompanied by injuries to

CHAPTER XIX

INJURIES OTHER THAN FRACTURES AND DISLOCATIONS

SPRAINS AND STRAINS

Industrial—Occupational—Athletic Injuries

INJURIES OF THE FOOT AND ANKLE

The chief injuries are crush, leverage, contusion and concussion.

Treatment.—In the treatment of injuries, minutes are precious and time may determine the end result.

The important considerations are:

I. What to do.
II. When to do it.
III. What not to do.

The great divide:

Is the skin broken?
Is there infection?

The *Bones* most likely to cause residual disability are the:

Os calcis.
Astragalus, and the
Metatarsals, especially the first.

The *Joint* injuries are chiefly:

1. Ankle subluxation.
2. Subastragalar disruption
3. Big toe metatarsophalangeal injury, and
4. Astragalo-scaphoid disturbance.

The painful jar caused by stepping on a cobblestone or a street car track usually localizes as a subastragalar sprain or strain.

Fractures, dislocations, combined fracture and dislocation, sprains, strains, and occupational, athletic, and military injuries of the foot and ankle are important because deformities and disabilities are reflected in carriage, posture, gait and comfort. Both acute and chronic conditions may be caused by direct injury, twists and crushing injuries of the foot, ankle, leg, and knee.

The industrial aspects of traumatic arthritis of the foot and ankle are very important.

After a fracture of the femur or tibia or an injury to the knee, a patient with an apparently excellent anatomical result may be unable

to stand or to walk because of pain in the foot and the ankle. Many excellent anatomical results are thus invalidated by residual foot and ankle troubles. One of the most serious types of arthritis in the foot involves the subastragalar joint, which controls lateral movement below the ankle. When this joint becomes the seat of arthritis as the result of injury, infection, or exposure, subastragalar fusion may be necessary.

Fracture of the os calcis is a common cause of arthritis of the foot.

Causalgia is a frequent complication or result of injuries to the nerves and blood-vessels of the foot, leg, and ankle.

In one year, *accidents in homes* in the United States accounted for 39,000 deaths and 170,000 severe crippling injuries. About one-half of the mishaps in homes are falls, and most of their victims are elderly persons. Carpets and rugs have a way of becoming misplaced or wrinkled, eyes may not be keen enough to see objects over which stumbling may occur, and muscles may fail to respond quickly enough to right the body in time to prevent disaster. Highly polished floors and poorly illuminated rooms, corridors, and stairways are also responsible for many injuries. A fracture may be sustained by falling out of bed. It would be a boon to many if beds were not over 1½ feet above the floor.

There is danger incident to standing on chairs or boxes. Even the household ladder may occasionally tip or slide. Many a crash has occurred because the housewife insisted upon carrying an armload of boxes up or down a stairway. The pile may be so high that the steps cannot be seen. Stair rails and floor covers are also sources of danger. If a small rug must be used on a highly polished floor at the top or bottom of a flight of stairs, it should be fixed in position with a few tacks. Bathroom hazards are numerous. Porcelain and tile tubs are slippery; a rubber mat on the bottom of the tub is an inexpensive safeguard. This mat should be sufficiently rough so that even "soapy" feet will not skid. There should be plenty of handles that can be grasped, especially by older people, in getting into or out of the bathtub. A bathtub with a side door has been invented.

THE TREATMENT OF INJURIES TO THE JOINTS OF THE FOOT AND ANKLE

The treatment of injuries to joints includes supportive and stimulative measures. Local treatment includes support, retention, massage, radiant heat, diathermy and inductotherm, galvanism, hydrotherapy, the whirlpool bath and the hot paraffin bath.

Injuries of even moderate severity are accompanied by injuries to

the local vessels which are followed by hemorrhage into the surrounding tissues. Heat causes a dilatation of the peripheral vessels, hyperemia of the skin, dilatation of the deep vessels, and an increase in the hemorrhage. When the hemorrhage occurs within a strong fascia, it increases the danger of ischemia. Volkmann's ischemic palsy in the lower extremity has been reported.

The proper *immediate treatment* is the use of a compress kept cold by frequent changes or the application of small pieces of ice. When the spasm is so strong that its alleviation is imperative, heat may be applied.

Unless an expert is at hand, no effort should be made to set a fracture. The injured limb should be placed in a splint and loosely tied. In impacted fractures, in which there is no danger of displacing the fragments, massage may be begun at once. In other fractures, it must be given with the greatest gentleness as soon as this danger has passed.

AUTOMOBILE INJURIES

Approximately 1,000,000 persons are injured in 2,000,000 automobile accidents every year. According to Foley, the total yearly financial loss due to automobile accidents ranges from $600,000,000 to $2,000,000,000.

Some of the serious automobile injuries involve the foot and ankle.

Automobile injuries peculiar to the foot and ankle are the following: (1) sprains sustained in getting into and out of the car; (2) crushing in doors; (3) tendinitis from excessive driving or tight brakes or clutch, and (4) metatarsalgia from inversion of the metatarsal arch or repeated trauma.

Because of the many facets, angles, and surfaces of approximation, contact, and movement in the foot and ankle, small discrepancies, small irregularities, small disproportions, and small incongruities of surfaces produce major discomforts and disabilities. While many patients with such slight abnormalities are entirely free from pain when they are not bearing weight and show no deformity on examination, they have disability and pain when they walk, go up and down stairs, or try to carry on their occupations.

The chief factor which misleads the doctor and the insurance company is a normal or nearly normal appearing roentgenogram. Serious mistakes are often made in determining the prognosis of traumatic injuries of the foot and ankle and in estimating disability due to such lesions. In the interpretation of the roentgenogram one must be careful to evaluate the positive and the negative factors. Even when the position and alignment of bones appear to be normal, there may be slight discrepancies causing bone, muscle, and tendon imbalance which will result in pain and disability. After the routine examination has been

completed and the notations have been entered, the examiner should repeat certain tests of muscle power, active movements, passive movements, tender spots, circulation, color, reflex tests, and skin tests for sensation, passing quickly from one area to another

The factors which determine the prognosis in industrial injuries are first, the nature of injury itself, second, the treatment that has been given, third, the time that elapsed between the injury and the beginning of proper treatment, fourth, the success of the treatment from the standpoints of mechanics, alignment, replacement and reduction, fifth, the results shown by roentgen-ray films made in at least 2 projections, studied carefully in front of a well-lighted view-box with additional stronger lights for the dark areas, and examined also with a magnifying glass to be sure that no defects have been overlooked, sixth, the patient's psychological attitude toward himself, his injury, and his employer, and seventh, factors such as the patient's home life from the economic standpoint

In the treatment of industrial conditions the watchword should be to *get the patient back to his occupation at the earliest possible moment* This should be done even though he may be unable to perform his complete duty, even though he may be used only in an advisory capacity, and even though he may be able to work for only a reduced number of hours per day

INDUSTRIAL OR OCCUPATIONAL CONDITIONS AFFECTING THE FOOT AND ANKLE

The financial loss sustained yearly by employers, insurance companies, and employees as the result of industrial injuries is colossal and staggering Another serious angle to this situation is the psychological breakdown

Causes of Industrial Disabilities —The chief causes of industrial disabilities are sprains, strains, ruptures, dislocations, and diseases occurring in the foot and ankle Trauma is much more frequently responsible than disease Probably the most important injury is fracture-dislocation of the ankle in which the lower ends of the tibia and fibula are fractured and the astragalus deviates or is dislocated medialward or, more commonly, lateralward The displacement of the involved bone and its fragments, the tearing of ligamentous support, the rupture of capsules, the hemorrhage into the tissues and fascial spaces, and the injuries to blood-vessels, nerves, and lymphatics are considerable The symptoms are pain and disability The patient says he is unable to stand or walk, and he is usually right The surgeon should not discredit a patient's statements with regard to pain and disability as a roentgen film suggesting complete reduction of a fracture or dislocation may be misleading

Traumatic Arthropathy.—An illustration of traumatic arthropathy is the condition at the subastragalar joint following a fall, when the victim lands on his heels without fracture of the astragalus or os calcis. The symptoms are pain in the heel on weight-bearing and inability to walk on rough or irregular ground without pain in the heel. The physical signs are tenderness on pressure along the medial, lateral or both aspects of the subastragalar joint lines. Pain in the subastragalar joint can be elicited on hammer percussion over the heel, on attempting to rise on the ball of the foot, and on lateral movement of the heel. Subastragalar arthrodesis is advisable in cases that are not free from pain after three months' treatment. Serious disability may be due to stiffness of the digits, with pain in the interphalangeal joints on movement, which follows the swelling incident to trauma or infection of the foot.

Occupational Considerations Involving the Foot and Ankle.—Every occupation involves the use or overuse of certain groups of muscles, tendons, bones, joints, and ligaments in certain positions. Therefore, each occupation has its own peculiar and particular type of trouble. There are certain occupations which are associated with serious hazards, such as burns and injuries by chemicals. Railroad workers and firemen are subject to fractures and dislocations. Policemen develop a certain type of foot condition due to their continued walking or standing on hard pavements. The pathological changes are in the nature of a strain exerted especially on the tissues supporting the longitudinal and metatarsal arches and on the plantar fascia. "Policeman's heel" is usually due to a calcaneal spur or bursitis or a pull on the attachment of the plantar fascia. The floorwalker in the department store is subject to foot strain. Excessive walking may result also in "World's Fair Heels," so designated because of the frequency of pain in the heels of persons who have visited World's Fairs. The condition called "Exposition Heels" may be a "gouty" disturbance of the feet of World's Fair visitors.

There are countless types of occupational injuries. Paradoxical weakness unassociated with objective changes suggests a so-called occupational neurosis.

Electrical Shock.—Langworthy found that when the current from a 1000-volt alternating or continuous circuit was allowed to flow through a rat for one second, abnormalities in the nerve cells of the brain or the spinal cord were demonstrated only in areas traversed directly by the current pathway. The electric current produced damage to nerve cells in experiments in which heat production was negligible. If a large current flows through the body for a considerable time, there is marked heat production which causes changes in nerve cells indistinguishable from those produced by the electric current alone.

Electrical burns of the foot or ankle are not uncommon in mechanics and engineers or electricians working on high-voltage lines or in a large power plant

Occupational palsies should be treated by psychotherapy or a change of occupation Local treatment alone is usually not sufficient Trauma can no more produce tuberculosis or cancer than it can produce measles, but it can determine where the lesion is to be located

Repeated slight injury or strain to the foot and ankle can result in a cumulative effect as severe as, and often more difficult to correct than that resulting from a sudden injury Such minimal traumata occur in persons who stand or walk a good deal in the course of their occupation These include dentists, barbers policemen, nurses, internes, orderlies, ballet dancers, waitresses, salesmen, floorwalkers, and taxi dancers

Prognosis —The prognosis in traumatic lesions depends upon (1) liability, (2) the extent of the injury, (3) the time that elapses before treatment is started and (4) the patient's attitude toward his injury The element of liability involves the question of whether the injury is personal or industrial The elements of psychology and desire for financial gain are very difficult to evaluate and overcome The duration of disability incurred in private life is much shorter than that of disability incurred in industrial pursuits There is a striking difference in the degree of pain and the duration of disability when another person or a company is liable for the injury If a painter falls off a ladder while painting his own house and breaks his ankle he will be back at work several weeks earlier than if his injury were sustained while working for a corporation If a foot or leg is injured in his own uninsured automobile, a man will not make as "big a case" as he would if struck by a chauffeur-driven high-priced car A college or professional football player minimizes his injuries, but when he becomes a bond salesman he may unconsciously exaggerate them A boy who breaks his fibula while playing "sand lot" football will minimize his complaints, but if a similar injury is due to his father's activities he will magnify his disability

It has been estimated that in the United States, **industrial accidents and diseases** entail an annual loss of $5,000,000,000 The number of fractures occurring annually ranges from 500,000 to 1,000,000

The **Board of Traumatic Surgery of the American College of Surgeons,** through Besley, proposes (1) improvement of the teaching of traumatic surgery in medical schools, (2) the provision of facilities for a more complete educational program on traumatic surgery, (3) a close working contact with large industries, (4) the appointment of a number of commissions, the personnel of which shall represent the

most advanced thought and the broadest conception of the approved and accepted methods of treatment of injuries.

Cutter states that as one visualizes the field of traumatic surgery, one pictures in the surgeon a person well trained in general surgery who has had also supplementary training in the field of trauma. The teaching of injury-surgery must include proper reporting of the injury, medico-legal factors, and an understanding of the compensation laws of the states and of insurance features.

In all cases of accident, the surgeon should obtain the history so minutely that he can analyze the mechanics of the injury as though he were with the patient when the accident occurred.

Insurance organizations are demanding shorter hospitalization, a quicker return to duty and earlier adjustments of claims. An employer is liable for compensation when an employee dies from preëxisting disease which is proved to have been aggravated or accelerated by an accidental injury sustained in the course of employment.

A traumatic surgeon must send his injured man back to work in good physical condition in the shortest possible time. He should keep accurate records. He must understand physical therapy. He should be prompt in completely reporting injuries. He must keep copies of every report.

Post-traumatic Neurosis.—Schaller and Somers discuss the psychogenic factors and precipitation point in post-traumatic neurosis and define a traumatic neurosis as a psychoneurosis following trauma, but which does not present any organic neurological background. The diagnosis is frequently made by the elimination of organic causes, and the only psychic factors seriously considered are those of litigation and the desire for compensation. These cases on analysis often yield a surprising wealth of other adverse mental complexes and influences, among which may be mentioned mental shock or fear states, poverty, deformities, lack of occupation or interest, unfavorable suggestion of different sorts, including suggestion of serious disability because of continued compensation, combined with introspection and meditation, wrong diagnoses, improper or unskilled treatment, desire for redress against alleged negligence, marital difficulties, bereavements, unfavorable environmental influence or return to arduous or unsuitable work.

A characteristic of the post-traumatic neurosis is the striking discrepancy between the claimed occupational inefficiency of the patient and the dearth of substantial physical manifestations and objective signs of disability. The establishment of a post-traumatic neurosis may be identified by a precipitation point which develops at a comparatively early period. The precipitation point may be recognized by a point of negative departure of efficiency, by a climax of adverse

mental influences occurring after meditation, and by the usual symptoms and signs of a psychoneurosis. At the precipitation point the complication of a psychoneurosis enters as a new factor of industrial disability and compensation. A post-traumatic neurosis, when established, runs a relatively long course and is resistant to treatment.

In traumatic hysteria, especially in women, by the time a lawsuit is settled contractures may have developed and may require surgery.

Farm Injuries—Agricultural Injuries.—Ghormley and Young reported a large series of farm injuries. There are about 26 million people on the farms. It is evident that agricultural accidents will take an important place alongside of industrial accidents.

The National Safety Council has made reports on this situation.

SPRAINS AND STRAINS

The statement that a sprain is worse than a break has been accepted as almost axiomatic but is grossly untrue. Sprains are not worse than breaks, but are usually neglected or inadequately treated, that is, they are not treated as serious accidents and the patients are dispatched with a bandage or adhesive strapping. Severe sprains of the foot should be treated with a plaster-of-Paris cast for a few days at least.

Sprains.—Sprains may be produced by a twist or a turn such as may occur in stepping on a street car track or cobblestones, stepping on or off of a curbstone, getting into and out of an automobile, catching the heel and stumbling or falling, jumping with the weight of the body thrown unevenly on one ankle, slipping on the sidewalk, or taking part in athletics.

Under normal conditions, a lateral roentgenogram shows a black triangular shadow just above the os calcis between the borders of the tibia and the Achilles tendon (Baetjer). This is due to the fact that this area is normally filled with fat. Any injury, sprain, or disease of the ankle joint causes the black triangle to disappear because the area becomes filled with either blood or inflammatory tissue. Obliteration of the triangle therefore indicates the presence of a pathological condition.

SPRAINED ANKLES—DIFFERENTIAL DIAGNOSIS (W. SCOTT)

	Type of injury	Swelling	Ecchymosis	Crepitus	Deformity	Tenderness	Response to ankle pads
Sprain	Usually an inversion twist while walking, lifting or running	++	0 +	0	Soft tissue only	Ligamentous	Improvement on walking 500 yard
Fracture	Usually an impact from a jump or a fall.	+++	+++	+	Bony	Bony	Aggravated.

The essential principles in the treatment of a sprained ankle are (a) adequate support, and (b) early weight-bearing.

The military shoe padded with felt makes an ideal dressing for sprained ankles.

The support should be used for at least three weeks.

An Outline of the Treatment of Sprains, Strains, or More Serious Injuries

1. Make no attempt to bear weight, not even to test the ability to stand.
2. Apply a very tight bandage—just within the limit of constriction
3. Elevate the leg—to at least the level of the hip.
4. Apply cold to the point of mild anesthesia.
5. Injection of novocain.
6. Correct gross malalignment of foot, ankle and leg.
7. Crutches—2 with rubber tips and rubber axillary shields.
8. Roentgen-ray—from at least two projection points.
9. Support—varies with severity of injury
   - (*a*) Gauze bandage.
   - (*b*) Ace bandage.
   - (*c*) Elastic adhesive bandage.
   - (*d*) Strapping adhesive.
   - (*e*) Cast—plaster—walking iron.
   - (*f*) Physical therapy—radiant heat—massage—inductotherm.
   - (*g*) Shoes—modifications. inside —felt.
rubber
metal.
outside—heels.
soles.
   - (*h*) Cane—rubber tip.

Injection of Procain Hydrochloride for Sprains.—A sprain indicates injury to supporting tissues. A sprained ankle should be protected against repeated injury and supported by a splint or by adhesive strapping and an elastic bandage until the injured tissues have had time to repair. It should be remembered that the injection of procain hydrochloride into a sprained joint to relieve the pain so that activity may be possible, may be a dangerous procedure. The pain which is present after such an injury is a warning that damage has been done and that further activity will increase the injury. A local anesthetic simply paralyzes the warning signal. Therefore its use is as much a mistake as the disconnection of a burglar or fire alarm because the sound is annoying. It is like giving morphine in a case of acute appendicitis. It is justifiable, however, in the case of a prize fighter or a star football player who must be tided over a brief transitional period of great moment.

Watson Jones advises, in every case of sprained ankle, that a roent-

genogram be made while the patient's feet are in forced inversion on film of both feet The injured foot is anesthetized by procain or ethyl chloride, or the patient is under pentothal-sodium In this manner he estimates the degree of dislocation of the astragalus which is an indication of the amount of capsule tear If the displacement of the bone is considerable he immobilizes the foot in a plaster-of-Paris cast for ten weeks, adding a walking iron or a sponge heel to the cast

In neglected cases of ankle sprain in which the ligaments have been seriously relaxed, he reconstructs the ankle with the tendon of the peroneus brevis muscle to permit recovery and prevent recurrence He finds that a very firm sponge attached to the heel portion of the cast is an excellent support for walking, and appears to be more comfortable than the walking iron

Treatment—Of Ankle Sprain
1 Minutes count
2 Who should walk and who should not
3 The surgeon must visualize the pathologic changes
4 Tight bandage
5 Strapping
6 High shoe
7 Hot water vs cold
8 Crutches
9 Cane
10 Importance of rest

Sprains and Strains
Ethyl chloride
1 Daily application
2 Massage
3 Strapping
4 Moderate use
Protected weight-bearing
Be sure there is no fracture or dislocation

The immediate treatment of a sprain is the reduction of active and passive congestion by the application of a snug resilient bandage, elevation of the foot and leg, and the application of cold almost to the point of numbing the tissues After three or four hours, heat is better than cold but the immediate application of heat may increase hemorrhage Good results from diathermy have been reported Very gentle massage should be started early, and active motion should be encouraged as soon as the patient will permit it

The high-laced shoe and a pair of crutches are ideal for walking. A cane is a poor substitute for two crutches.

Serious conditions often follow simple sprains. In some cases of deep muscle sprain or bruise, 0.5 cc. of 1 per cent novocain injected into the tender area will give relief from pain during the early acute stages. In some instances nerve blocking can be employed.

Osgood laid down three good rules to be followed in the treatment of sprains, viz.: (1) Be sure the sprain is not a fracture or a sprain-fracture. (2) Determine the exact anatomy of the lesion by ascertaining the method of its production and its mechanical necessities. (3) Protect the torn ligament or ligaments usually with adhesive plaster and allow immediate function.

Leriche and Fontaine advise the use of periarticular infiltrations of from 10 to 25 cc. of 1 per cent novocain in the treatment of sprains and traumatic arthritis. The dose may be repeated daily. Leriche contends that in sprains there is no lesion of the ligaments even when edema and a marked subcutaneous hemorrhagic suffusion are present, and that the pain is caused by the contracture. He affirms that any sprain can be quickly relieved by allaying the pain in the tissues. For this purpose he injects procain hydrochloride deep into the painful area. This causes the disappearance of symptoms within a few hours. A sprain is essentially an injury to the nerves of the ligaments, and these nerve terminals are the point of origin of a reflex acting on the joint structures and the vessels of the muscles.

Leriche emphasized the importance of giving an early injection before the appearance of edema and hydrarthrosis.

Brunschwig and Jung found that the sensibility of a joint is primarily a periarticular response, due to the abundance of nerve endings in the joint capsules and periarticular ligaments. In sprains, pain is due primarily to trauma of the periarticular innervation. Reflex muscular rigidity involving the injured joint also has its origin in the traumatized nerves of the joint capsule and ligaments. Periarticular injections of novocain have a definite therapeutic value. When the pain and reflex muscular rigidity are abolished, almost normal function is possible. In some instances, several injections are necessary.

Moorhead favors early mobilization of injured joints, and permits prompt use of the part unless it causes added pain and swelling.

ATHLETIC INJURIES

Every athletic sport has its particular type of injury such as those that occur during sprints, marathons, hurdles, high jumps, tennis, golf, skiing, and mountain climbing. These are usually due to repetitive strain which may be multiple minimal or multiple submaximal.

Every athlete should be very careful of his feet, ankles, and legs before the athletic season begins In preparation for athletic contests they should be massaged, sprayed, and exercised Cross makes the statement "The condition found in golfer's foot is not of necessity confined to golfers It is a very common distortion and may occur in any foot that is overused" There is no doubt that when women wearing high heels go into the locker room and change to golf shoes or tennis shoes they often disturb the muscle and tendon balance of their feet to such a degree that the benefit to be derived from the game will be more than offset

Specific Athletic Activities	
Baseball	Skiing
Football	Track
Soccer	Running
Golf	Hurdles
Tennis	Broad jump
Squash	High jump
Squash racquet	Pole vault
Handball	Discus
Bowling	Horseback
Rowing	Archery
Swimming	Badminton
Diving	Wrestling
Fencing	Weight lifting
Skating	

Lord Dawson found that proficiency in games often exists with deficiency of frame and function Games, unless correlated with basic physical training, can cause serious overstrain Sports and games are the fulfillment of physical training and should rest on it, for planned physical exercises increase the strength, control and response of the body Moreover, physical training develops certain qualities which are basic to sound physical education, *posture, poise, flexibility* and rhythm of movement and efficient respiration

Physical education needs the guidance of trained physicians In the future those who aspire to be medical officers of schools should be required to include in their training a basic knowledge of physical education

Athletic teams should be under the supervision of competent physicians Coaches should insist that unless players are in the "pink" of condition they should not engage in strenuous athletics Players who have received a minor injury or are temporarily indisposed should not be allowed to remain in the game

Tennis Leg.—"Tennis leg" is the term applied to the condition resulting from rupture of a part of the gastrocnemius group of muscles

by a sudden movement made while playing tennis. Hemorrhage occurs from a vein or artery. There may be a tear of the plantaris or of some of the fibers of the gastrocnemius or soleus muscles. Rupture of the Achilles tendon is very uncommon.

Football.—The response to treatment of injuries to the foot and ankle due to football differs considerably from that of similar injuries in men and women with poor muscles and persons of middle age. Rough or excessive massage invariably aggravates the symptoms, and overuse causes severe symptoms.

Golf.—Golf may cause foot and ankle strain. Beginners who do not "carry through" suffer from low back strain involving the erector spinæ muscles and the lumbo-sacral and sacro-iliac ligaments. Gray reported on 3 patients who presented similar symptoms. Their ages ranged from thirty-five to forty-five years. The side involved was the left, all of the patients being right-handed. The cause was golf practice with short-distance clubs which involved a brisk snappy twist of the trunk. Practice is usually worse than playing.

Golfer's Big Toe.—I have seen golfers who developed hallux rigidus with exostoses and an actual rim of bone encircling the head of the first metatarsal with severe arthritis. This was due to trauma from excessive pivoting which began in childhood during the time the epiphyses were developing and therefore more vulnerable to trauma than in later life. Pain in the foot and leg of a golfer is practically always due to imbalance, overactivity, fatigue, or a combination of these causes.

It would be a boon to many men, especially those who are overweight, if golf courses were only 13 holes long. Many golfers find that the last 4 or 5 holes are hard on their feet and legs. The type I refer to are men from 20 to 50 pounds overweight, who have been ingesting too much meat, fish, and other animal proteins, too much starch, sugar, and salt, and too much fluid. The last 4 or 5 holes give them no pleasure, and they are glad when the 18th hole is reached. Many such persons can spare themselves and prevent considerable fatigue and pain by shortening their strides 2 or 3 inches. They should not hurry, and should rest for a few moments at every tee.

Golfers may suffer from pain at the attachment of the plantar fascia to the os calcis, from tenosynovitis of the Achilles, and from pain in the region of the big toe joint.

In playing golf, the anterior portion of the left foot of right-handed players and the anterior portion of the right foot of left-handed players is brought into unusual service. This is apparent when the body weight comes over onto the anterior portion of left or right foot respectively as the golfer makes a right-handed or left-handed drive. There is no doubt that in most cases the foot suffers more during practice

than during play During practice, one goes through the same movements of the arms, legs, body and feet in rapid succession and throws unusual strain on these structures, whereas in playing, the ball is hit and the player then walks a certain distance, using other muscles I therefore say that practice may cause much more strain than the playing of golf or any other game Cross described golfer's foot as a troublesome affliction which may be developed by any golfer It is an acute condition resulting from distortion of the foot due to a "broken" arch in the anterior metatarsal curved area It makes the player fretful and interferes with play There is no doubt that in pivoting, an undue strain is thrown on the transverse arch However, in my experience, most of the complaints that arise during and after golf are in the longitudinal arch area, and I cannot see any justification for the term "golfer's foot"

The Prize Fighter —The prize fighter must have good feet because he is dependent upon such activities in training as road work, bag punching, and training bouts and during a contest he is constantly stepping around on his toes, "bobbing" and "weaving"

Badminton —Badminton has its own specific injuries due to the quick starts and stops which throw much strain on the calf group

Wrestling —The importance of the toe hold in wrestling is shown by the pain reaction due to a tremendous reflex

Ballet Dancers Injuries —The ballet dancer is subject to specific foot and ankle injuries during her training, practice, preparation, and performance

Among these injuries are included

1 Ligamentous injury
2 Fractures
3 Sesamoid injuries
4 Muscle injury
5 Tendon injury

During taps the metatarsal areas suffer much trauma During the execution of aerials, there is much pounding of the metatarsal heads and sesamoids Insoles of sponge rubber are helpful During acrobatics "anything can happen"

The split is a stunt that accomplishes complete abduction of the legs

Tears of the triceps surae or of the plantaris are serious injuries

Tendinitis, especially of the Achilles or anterior tibial may be due to overactivity

Rupture of Ligaments —The most important injury to a ligament in the foot is rupture of the fibular collateral band If unrecognized and unhealed, it produces a weak, inadequate, incompetent ankle which may be vulnerable to strains and sprains for many years

A person with this condition may become disabled by twisting his ankle by stepping on a cobble-stone.

Rupture of Plantar Fascia.—This injury is prone to occur during a jump as when a baseball player springs from the ground to catch a high ball.

It is an injury that causes disability for three or four weeks.

It is treated by adhesive strapping or a plaster-of-Paris cast.

A Protective Wrapping for the Ankle.—The vulnerability of the ankle has long been known to athletes and trainers and protective bandaging is commonly practiced. The usual wrapping consists of turns taken in a "figure 8" fashion around the malleoli and foot, crossing at the anterior aspect of the astragalus. When critically examined by Quigley, Cox and Murphy this bandage really accomplishes little; neither lateral nor anteroposterior motion is greatly limited, and little protection is afforded against sprain or fracture.

For the past fifteen years at Harvard College every student who participates in contact sport has been taught a method of wrapping the ankle which considerably limits lateral motion without interfering appreciably with flexion or extension. During this period, not one player wearing this wrapping has suffered a complete rupture of an ankle ligament. When sprains do occur they are minor, and the average period of disability, before return to full athletic participation, has been only eight days.

A considerable number of former college athletes, having learned to apply the wrapping as undergraduates, have used it enthusiastically on week-end skiing expeditions. With the growing popularity of winter sports and the high incidence of injuries to the ankle among amateur skiers and skaters, a description of the method seemed worthy of publication.

The technic as described by Quigley, *et al.* is as follows:

Bandages are cut to 100 inch (254 cm.) lengths from $2\frac{1}{4}$ inch (5.7 cm.) non-elastic ribless muslin tape and thoroughly shrunk by washing in extremely hot water before use. The wrapping is applied over the inner of two pairs of smoothly fitting socks. The toes are placed on the edge of a chair, and the ankle is held firmly at an angle of 90 degrees. The end of the bandage is placed at the lateral malleolus and unrolled snugly, without wrinkles, over the proximal end of the first metatarsal, across the sole, upward, crossed at the center of the ankle joint and back over the medial malleolus (Fig. 238).

At this point it is angled sharply downward across the lateral aspect of the os calcis, carried across the sole, upward on the medial aspect of the foot and over the lateral malleolus (2, 3 and 4). Again it is angled sharply downward, this time over the medial aspect of the os calcis, carried across the heel and up around the medial malleolus

(5, 6 and 7) The remaining turns are of the "figure 8" type around the tarsus and ankle at and just above the malleoli (8 to 14 inclusive). A "figure 8" turn of 1 inch (2.5 cm) adhesive tape anchors the final turns.

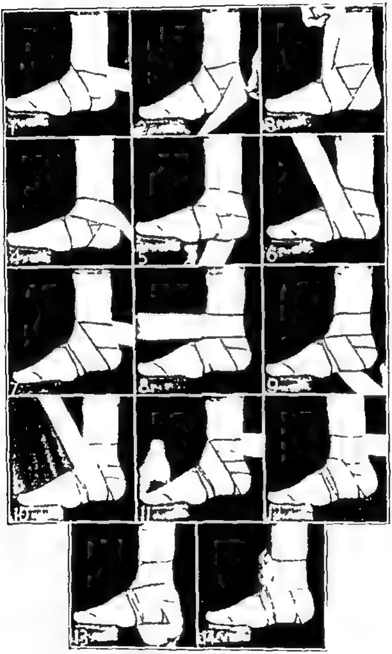


FIG 238 — Protective wrapping for the ankle (Quigley, Cox and Murphy, courtesy of Jour Am Med Assn)

BURNS OF THE FOOT AND ANKLE

Burns about the foot and ankle may be extremely debilitating and if not managed correctly, may lead to contractures necessitating

surgical correction. Thus, adequate early management with the view toward preventing disturbances in gait and weight-bearing is important.

Burns may be produced by physical agents, chemicals, or traumatic or frictional factors. The physical agents are heat and cold, the former is usually in the form of water, oil, lead, or steel. The chemical agents are caustics such as phenol and lye. Examples of traumatic or frictional burns are those caused by lamps, electric currents, cinders and scraping. Burns are divided into those of the first, second, and third degree, according to the depth of the lesion. A burn of the first degree involves only the superficial layer of the skin, and is manifested by hyperemia. A burn of the second degree involves all the layers of the skin, while a burn of the third degree involves the deep tissues.

Shock, which is common in severe and extensive burns, may be slight or so severe as to cause death.

According to Wells, three principles of special importance in the treatment of extensive burns are: (1) the prevention of dehydration. (2) the maintenance of asepsis; and (3) the promotion of epithelialization. In 1925, Davidson introduced tannic acid in treatment of burns. The tannic acid is applied every fifteen minutes for eight hours. If the wound was soiled at the time the burning occurred, antitetanus serum should be given.

Any person whose leg is burned by a chemical should remove his shoe and stocking immediately, in order to minimize the burn, and prevent severe infection.

In a simple burn, unguentine ointment, amertan, picric acid ointment, paraffin, or equal parts of olive oil or linseed oil and lime water may be employed. Open-air treatment which protects the skin may be given by exposing the wound to the breeze from an electric fan.

It is necessary to protect a wound from infection or, if infection is present, the wound must be kept absolutely clean. All devitalized tissue should be removed. Tendons, joints, capsules, and other structures must be carefully handled. In the late treatment of burns, skin grafting may be employed. When possible, the grafts should be autogenous.

Many of the clinical symptoms observed in cases of extensive burns are due to excessive concentration of blood. Because of the constant loss of blood plasma through the burned area, the fluid, mineral, and protein intake should be increased and maintained at a constant value. Large quantities of fluid may be administered intravenously. The last choice is the transfusion of whole blood, serum, or plasma.

Sherman recommends that all burns should be thoroughly dried and then covered with an air-tight coating of neutral paraffin wax which includes ½ inch of the margin of the skin immediately adjoining the burned area. After the application of the first film of wax, a thin

layer of cotton is applied and incorporated into the first film by impregnating it with wax applied with a fine varnish brush or an atomizer The wax "sets" in a few seconds, the dressing is then completed by covering the entire waxed area with cotton and bandages All burns are redressed every twenty-four hours Blebs are punctured immediately

In third- and fourth-degree burns with loss of much tissue, granulations should be sterilized by the Carrel-Dakin method and skin should be grafted at the earliest opportunity Burns are clinically and bacteriologically sterile during the first few hours, but become infected as soon as the skin begins to slough or becomes necrotic

Débridement is as important in the treatment of burns as in the treatment of any other wound Chemotherapy can be instituted in a manner similar to that used in the treatment of potentially infected wounds

Burns may be treated with a 1 per cent aqueous solution of gentian violet applied by means of a swab or a spray or in a jelly The application is repeated every two hours for the first twenty-four

In suitable cases, the "closed method" is effective Under general anesthesia the burned area is carefully cleansed with soap and water, using rigid surgical technic The area is next covered with heavily impregnated vaseline gauze, which is in turn covered with a sponge, supplying even, gentle pressure, and tightly bandaged

Tannic Acid —Seeger uses a solution with a hydrogen-ion concentration of 7 4 which he obtains by adding 3,975 gm of pure anhydrous sodium carbonate and 25 gm of tannic acid to 500 cc of water It produces rapid tanning, and the tanned membrane formed is more pliable than that produced by solutions with low hydrogen-ion concentrations

For widespread burned areas that require the release of deformity and the covering of a raw surface, Blair, Brown, and Hamm recommend the thick split graft When the best possible early bearing surface and cosmetic results are desired, they use full-thickness grafts unless it is necessary to employ pedicle flaps (Figs 239 and 240)

In the treatment of burns involving the foot and ankle, the most important consideration is the prevention of contractures of the toes and Achilles tendon This should be kept in mind while the eschar is forming A posterior molded right-angled splint will prevent foot-drop Traction may have to be applied to one or several toes Physical therapy should be instituted as soon as the eschar has come off, and there is no danger of fissure formation which enhances the possibility of secondary infection and delayed healing If the tendons and their sheaths have become involved in the scar tissue, early physical therapy is recommended In occasional cases a secondary operation

is necessary to provide a smooth gliding bed for tendons. This is accomplished either by transplantation or by freeing the adhesions.

DECUBITUS

Decubitus, or pressure sore, may occur on the heel as a result of local pressure and impairment of circulation. Lesions of this type occur most frequently when the resistance of the tissues has been lowered by age, chronic disease, injury, or nerve involvement. They are initiated by pressure and often favored by some slight injury or irritation. In the ambulatory patient they may be due to the counter of the shoe. In bedridden patients they are due to constant contact with the bed sheets plus slight movement. Latimer uses a fresh 5 per cent aqueous solution of tannic acid as a simple treatment. I have obtained successful results with elastic adhesive tape. The entire lesion is sealed with tape for two or three days at a time, this seems to enhance granulation and healing. The secretion is then wiped off and more tape is applied. Bismuth violet is effective. In bedridden patients a simple rubber ring, or cotton doughnut to lift the heel from the bed sheets is used, while an aqueous solution of gentian violet is applied to the ulcer. Uhlman recommends vaseline that has been irradiated with Radon B.

SKIN GRAFTING ON THE FOOT AND ANKLE

Conditions often requiring the transplantation of skin to the foot and ankle are flames and hot-water burns, oil burns, electrical burns, destruction of covering tissues as a result of severe infection or excessive irradiation, crushing and avulsing injuries and burns due to powerful chemicals. The principles laid down recently by Koch in his article on skin transplantation to the hand may well serve as the foundation upon which to base the principles of transplantation of skin to the foot and ankle.

To replace the destroyed tissue with normal tissue at the earliest moment that it can be safely accomplished, is a sound surgical principle. However, it must be remembered that if a patient's vitality is below normal, transplanted tissues heal slowly. The repeated losses of small amounts of blood, long-continued suppuration and perhaps lack of proper food are important factors. A patient can be made a better risk by blood transfusion, sunshine, vitamin therapy, ultraviolet radiation and good food, especially proteins.

The following principles are adapted from Koch with modifications applicable to the foot and ankle.

1. The more tissue one attempts to transplant the greater is the need for nutritive blood serum to maintain life. A graft is tissue completely

detached from its original blood supply and transferred to a new site, a flap receives part of its original blood supply and is not completely transplanted in one stage

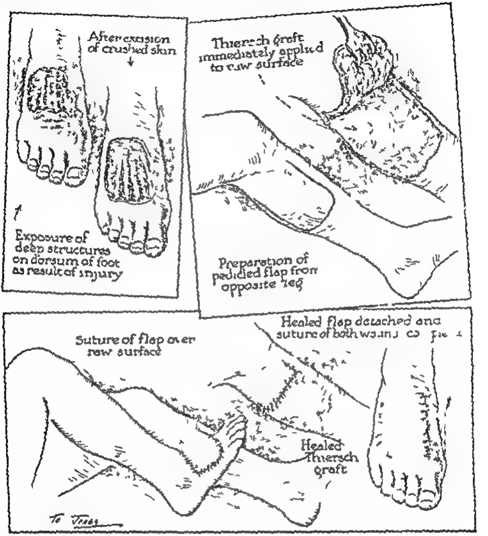


Fig 239 — Plastic operations on skin of foot and ankle (Reproduced with permission of Johnson & Johnson)

2 Although a thin graft will "take" better than a thick one, its functional result is inferior The thinner the graft the less adequately it protects the underlying tissue, the more easily it breaks down when subjected to irritation or trauma, the more certain it is to contract and possibly cause flexion contracture at a joint

3 The thicker the graft that can be applied with assurance of survival, the more satisfactory will be the end result

4 When tendons, nerves, blood-vessels, bones or joint capsules are exposed it is necessary to give them a protective covering of subcutaneous tissue as well as skin The only successful method of accomplishing this is by the use of a pedunculated flap

is necessary to provide a smooth gliding bed for tendons. Thi- accomplished either by transplantation or by freeing the adhesions

DECUBITUS

Decubitus, or pressure sore, may occur on the heel as a result of lo pressure and impairment of circulation. Lesions of this type oc most frequently when the resistance of the tissues has been lowered age, chronic disease, injury, or nerve involvement. They are initia by pressure and often favored by some slight injury or irritation. the ambulatory patient they may be due to the *counter* of the sh In bedridden patients they are due to constant contact with the l sheets plus slight movement. Latimer uses a fresh 5 per cent aque solution of tannic acid as a simple treatment. I have obtained succ ful results with elastic adhesive tape. The entire lesion is sealed w tape for two or three days at a time, this seems to enhance granulat and healing. The secretion is then wiped off and more tape is appli Bismuth violet is effective. In bedridden patients a simple rubber ri or cotton doughnut to lift the heel from the bed sheets is used, wl an aqueous solution of gentian violet is applied to the ulcer. Uhln recommends vaseline that has been irradiated with Radon B.

SKIN GRAFTING ON THE FOOT AND ANKLE

Conditions often requiring the transplantation of skin to the fo and ankle are flames and hot-water burns, oil burns, electrical bur destruction of covering tissues as a result of severe infection or exc sive irradiation, crushing and avulsing injuries and burns due powerful chemicals. The principles laid down recently by Koch his article on skin transplantation to the hand may well serve as t foundation upon which to base the principles of transplantation skin to the foot and ankle.

To replace the destroyed tissue with normal tissue at the earli moment that it can be safely accomplished, is a sound surgical princip However, it must be remembered that if a patient's vitality is bel normal, transplanted tissues heal slowly. The repeated losses small amounts of blood, long-continued suppuration and perha lack of proper food are important factors A patient can be made better risk by blood transfusion, sunshine, vitamin therapy, ult violet radiation and good food, especially proteins.

The following principles are adapted from Koch with *modificati* applicable to the foot and ankle.

1. The more tissue one attempts to transplant the greater is the ne for nutritive blood serum to maintain life. A graft is tissue complet

detached from its original blood supply and transferred to a new site, a flap receives part of its original blood supply and is not completely transplanted in one stage

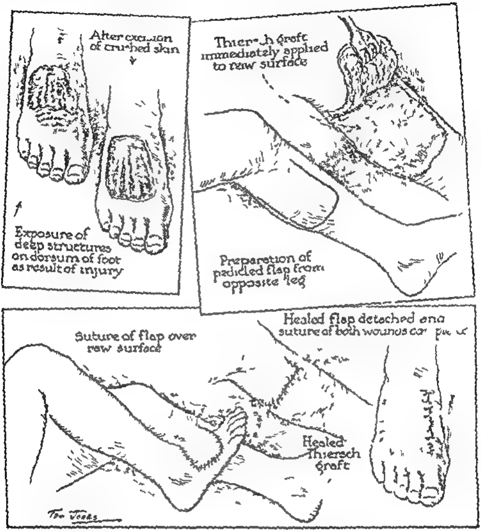


FIG 230 —Plastic operations on skin of foot and ankle (Reproduced with permission of Johnson & Johnson)

2 Although a thin graft will "take" better than a thick one, its functional result is inferior The thinner the graft the less adequately it protects the underlying tissue, the more easily it breaks down when subjected to irritation or trauma, the more certain it is to contract and possibly cause flexion contracture at a joint

3 The thicker the graft that can be applied with assurance of survival, the more satisfactory will be the end result

4 When tendons, nerves, blood-vessels, bones or joint capsules are exposed it is necessary to give them a protective covering of subcutaneous tissue as well as skin The only successful method of accomplishing this is by the use of a pedunculated flap

is necessary to provide a smooth gliding bed for tendons. This is accomplished either by transplantation or by freeing the adhesions.

DECUBITUS

Decubitus, or pressure sore, may occur on the heel as a result of local pressure and impairment of circulation. Lesions of this type occur most frequently when the resistance of the tissues has been lowered by age, chronic disease, injury, or nerve involvement. They are initiated by pressure and often favored by some slight injury or irritation. In the ambulatory patient they may be due to the counter of the shoe. In bedridden patients they are due to constant contact with the bed sheets plus slight movement. Latimer uses a fresh 5 per cent aqueous solution of tannic acid as a simple treatment. I have obtained successful results with elastic adhesive tape. The entire lesion is sealed with tape for two or three days at a time, this seems to enhance granulation and healing. The secretion is then wiped off and more tape is applied. Bismuth violet is effective. In bedridden patients a simple rubber ring, or cotton doughnut to lift the heel from the bed sheets is used, while an aqueous solution of gentian violet is applied to the ulcer. Uhlman recommends vaseline that has been irradiated with Radon B.

SKIN GRAFTING ON THE FOOT AND ANKLE

Conditions often requiring the transplantation of skin to the foot and ankle are flames and hot-water burns, oil burns, electrical burns, destruction of covering tissues as a result of severe infection or excessive irradiation, crushing and avulsing injuries and burns due to powerful chemicals. The principles laid down recently by Koch in his article on skin transplantation to the hand may well serve as the foundation upon which to base the principles of transplantation of skin to the foot and ankle.

To replace the destroyed tissue with normal tissue at the earliest moment that it can be safely accomplished, is a sound surgical principle. However, it must be remembered that if a patient's vitality is below normal, transplanted tissues heal slowly. The repeated losses of small amounts of blood, long-continued suppuration and perhaps lack of proper food are important factors. A patient can be made a better risk by blood transfusion, sunshine, vitamin therapy, ultraviolet radiation and good food, especially proteins.

The following principles are adapted from Koch with modifications applicable to the foot and ankle.

1. The more tissue one attempts to transplant the greater is the need for nutritive blood serum to maintain life. A graft is tissue completely

detached from its original blood supply and transferred to a new site, a flap receives part of its original blood supply and is not completely transplanted in one stage

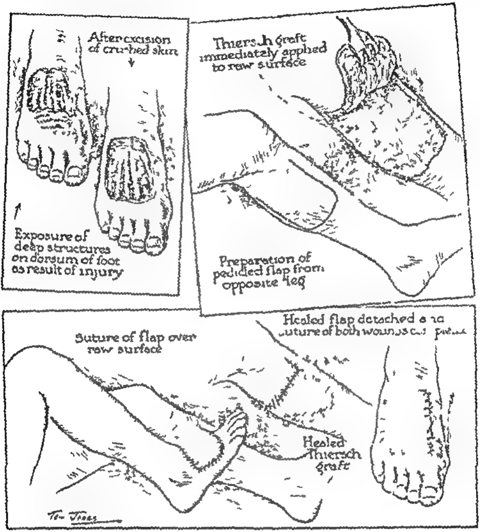


FIG 230 —Plastic operations on skin of foot and ankle (Reproduced with permission of Johnson & Johnson)

2 Although a thin graft will "take" better than a thick one, its functional result is inferior The thinner the graft the less adequately it protects the underlying tissue, the more easily it breaks down when subjected to irritation or trauma, the more certain it is to contract and possibly cause flexion contracture at a joint

3 The thicker the graft that can be applied with assurance of survival, the more satisfactory will be the end result

4 When tendons, nerves, blood-vessels, bones or joint capsules are exposed it is necessary to give them a protective covering of subcutaneous tissue as well as skin The only successful method of accomplishing this is by the use of a pedunculated flap

5. Certain complicating factors prevent the survival of a transplant. Chief of these is infection. A whole thickness graft should never be laid over a granulating surface or the yellow base left by the excision of exuberant granulation tissue. Furthermore, only in unusual instances should one be willing to lay a flap, with an assured blood supply, over a granulating surface, because of the disastrous effect of even a few bacteria on the vulnerable subcutaneous tissue.

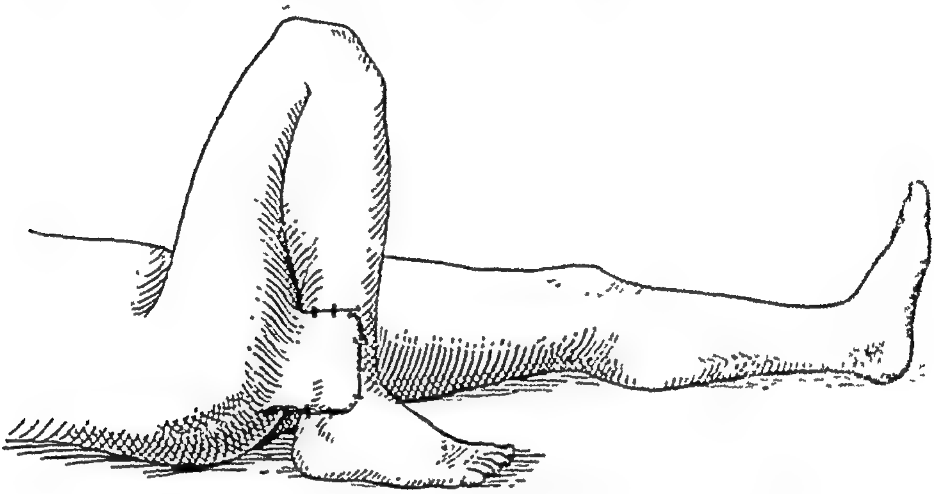


FIG. 240.—Flap graft from buttock to ankle. (After Potel.)

6. The extravasation of even a small amount of serum or blood underneath a graft will prevent the ingrowth of budding capillaries. Thus, every portion of the graft should be pressed smoothly against the underlying raw surface and held in position with accurately placed sutures and a pressure-dressing.

7. Redundant granulation tissue should be excised cleanly to provide a smooth yellow base over which to apply a graft of intermediate thickness. If an infected wound has been dressed with scrupulously clean care from day to day and with constant application of sponge pressure outside the sterile dressing, the granulations may become so firm and healthy that no excision of granulation tissue is necessary. Congested, soft granulating surfaces which project above the level of the surrounding skin do not form a favorable base upon which to lay a graft.

8. At the time of operation the donor site is prepared with plain white soap and water and without antiseptics. The graft is secured and wrapped in moist gauze before the dressings are removed from the area to be grafted. The donor site is dressed with a few thicknesses of fine-meshed gauze saturated with petrolatum next to the raw surface.

9. The dressings are removed from the foot (site to be grafted) and the area irrigated with warm saline solution. The more rapidly the

graft can be applied to the raw surfaces, the less opportunity is there for congestion of granulation tissue to develop

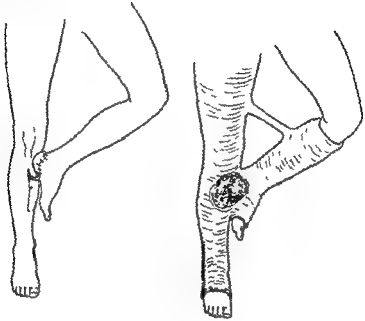


Fig 241

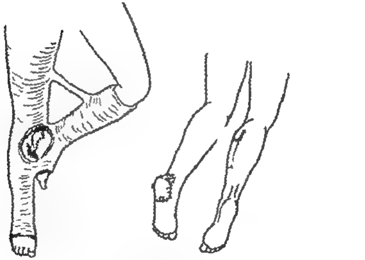


Fig 242

Figs 241 and 242 —Repair of deep skin defects (Ghormley courtesy of Am Assn of Orthop Surg)

Fig 241 —Fifth stage Pedicle is sutured to defect after cast has been applied

Fig 242 —Sixth and seventh stages The proximal end of the pedicle is partially severed in the sixth stage In the seventh stage it is completely severed and sutured over the defect

10 If there is some uncertainty as to whether infection is completely under control, Carrel tubes are incorporated into the dressing

so that it can be kept moist by four or six hourly injections with salt solution without disturbing the dressing or releasing the pressure. Penicillin is a valuable adjunct.

11. The primary dressing is left undisturbed for four or five days; and for as long as eight days if the graft has been laid over a recent wound and if no symptoms of developing infection—fever, redness and swelling above the involved area, throbbing and pain—have appeared.

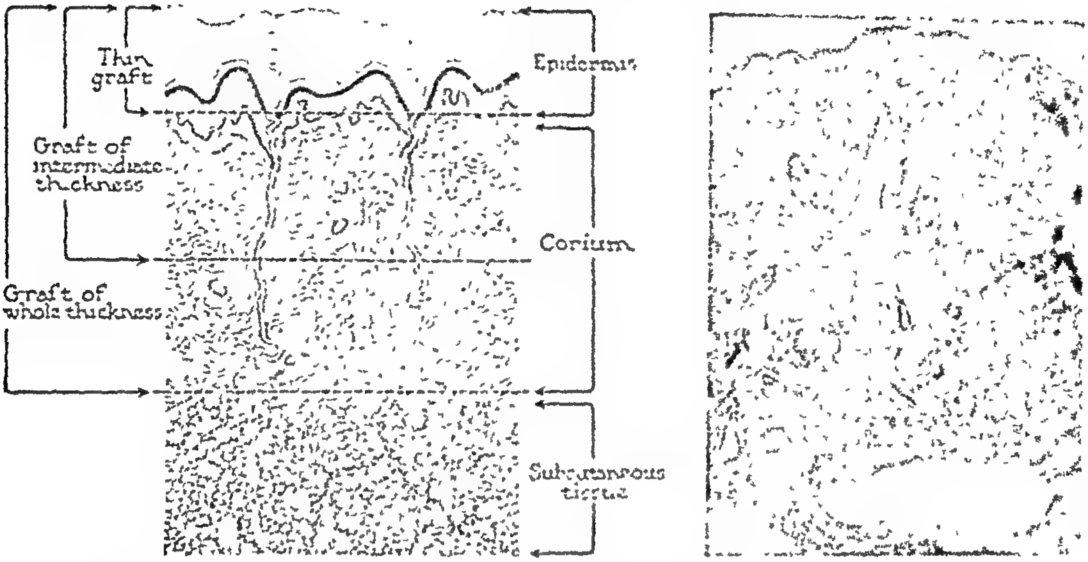


FIG. 243.—Diagram showing skin in cross-section, and thickness of skin included in different types of graft. In the photomicrograph of a similar section of skin, at the right, can be seen the numerous epithelial elements within the corium—hair follicles, sebaceous and sweat glands, from which the epidermis is rapidly reformed, even though the entire epidermis and a part of the corium have been removed for use as a graft. (Koch, courtesy of Surg., Gynec. and Obst.)

12. The first dressing is removed with every care to avoid pulling away healing epithelium. Sutures are removed, and any redundant portions of the graft are cut away. If the graft is pink and dry a simple dry dressing or a petrolatum gauze dressing is reapplied and pressure maintained over the wound for another four or five days. If any small pools of pus or wound secretion are present they are wiped away with sterile applicators and the same type of moist dressing is applied as was used during the preoperative period. The dressing is then changed twice daily, and the pressure and splinting are maintained until healing is complete.

13. When a weight-bearing surface such as the sole of the foot requires skin grafting, it must be borne in mind that the subcutaneous fat pad is as important as the skin, and function will be seriously impaired unless an adequate fat pad is transplanted with the skin. Therefore, pedicle flaps must be used for such transplants.

THE POSTOPERATIVE CARE OF FULL-THICKNESS AND SPLIT-THICKNESS SKIN GRAFTS*

The postoperative care is as follows

Following operation considerable care must be devoted to the graft in order to assure a satisfactory result The postoperative care is as follows

At the time of operation curling of the split-thickness graft is prevented by "backing" the graft with isinglass plaster, which remains attached to the graft Then dressings of one thickness of xeroform gauze followed by three or four thicknesses of dry gauze and sea sponges† are applied The sea sponges are bandaged into position until there is firm pressure on the graft The pressure used is estimated by the operator to give about the same resistance as a well-developed muscle during contraction

The extremity is immobilized in a plaster cast which is applied after the dressings are in place A window is then cut in the cast to allow moisture from the sponges to evaporate This window can later be enlarged to facilitate the changing of dressings, and the remaining portion of the cast will continue to immobilize the extremity

In the case of the split-thickness graft the first dressing is changed on the fifth postoperative day while with the full-thickness graft the first dressing is changed on the seventh postoperative day

At the time of the first dressing it will be found that the sponges have dried out until they are quite firm and that they have assumed the contour of the surface upon which they were placed These sponges are carefully removed and washed in a solution of mercury bichloride (1 to 5000) Upon removing the remaining dressings it will be found that xeroform gauze separates from the graft very easily It should not be lifted up but should be rolled back to avoid elevating the graft Some of the pieces of isinglass plaster will adhere to the xeroform gauze and be removed with the dressings while others will remain firmly attached If the removal of the isinglass plaster in any way disturbs the graft it should be left in position until the dressings are changed the second time Any drainage that is present between the grafts should be picked up with a cotton sponge moistened with saline until the area is quite clean, then the grafts and the surrounding skin are thoroughly cleansed with ether All the granulating areas between the grafts are then touched with a 2 per cent solution of silver nitrate This solution should be prepared fresh for each case and should be

* As recommended by Dr Alfred O Adams

† The sea sponges used are of an excellent quality and can be obtained from the American Sponge & Chamois Company Inc 609 Montgomery Street San Francisco Calif by specifying Mediterranean silk sponges sizes TZ150 TZ200 and TZ250 retailing at $1 50 $2 00 and $2 50 respectively

kept in a brown bottle. The dressings are then reapplied the same as at the time of operation, applying first one thickness of 2 per cent xeroform gauze followed by dry gauze and sea sponges* bandaged under pressure.

It is essential that the xeroform gauze be well saturated with the ointment (2 per cent xeroform in vaseline) and that the gauze used for this purpose have a fine mesh. It can best be prepared by spreading a 3- or 4-inch bandage in the bottom of a small covered tray, placing the ointment between a few of the layers and then sterilizing in the autoclave.

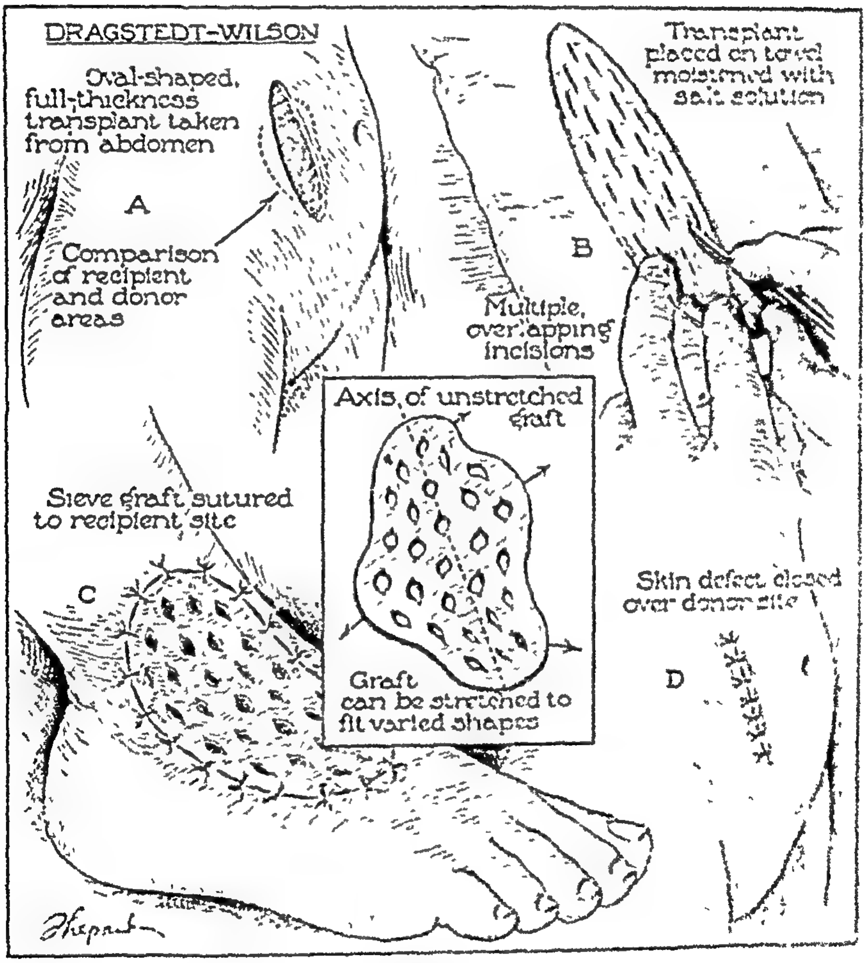


FIG. 211.—Sieve type of skin graft is applied to the defects of the dorsum of the foot and ankle. (Courtesy of Johnson & Johnson.)

If only one thickness of the gauze is used over the graft any serious drainage can pass through and be absorbed by the overlying dry gauze.

The isinglass plaster used is manufactured by both Johnson & Johnson and Bauer & Black, and can be obtained at almost any drug store.

Subsequent to the first dressing the dressings are changed every

* See footnote (†) on page 381.

second day in the manner described above, and sponge pressure is maintained for a period of ten to fourteen days, or until the graft is firmly attached. Immobilization in plaster is necessary until the area is almost healed. In the case of the split-thickness graft it will be found that, even though the grafts are placed very close together at the time of operation, they will contract some, leaving a space between the grafts. These grafts will rapidly fill in this intervening space, leaving very little scar and practically no contracture.

In the case of the full-thickness graft, the line of suture everting the normal skin edges to allow for shrinkage can be cut at either the first or second dressing. The remaining sutures used to attach the graft to the skin edge can be removed at the time of the third or fourth dressing. Otherwise the care of this type of graft is essentially the same as given above. At the time of each dressing all of the granulating points are painted with a 2 per cent solution of silver nitrate. Sponge pressure is maintained until the graft is firmly adherent to the underlying surface. At each dressing it is essential that the graft be thoroughly cleaned, excising any of the borders that are not viable and carefully removing the epidermal surface as it separates.

WOUNDS OF THE FOOT AND ANKLE

Crushing injuries, stab wounds, gunshot wounds, and perforating wounds are common in the foot and in and around the ankle.

Crushing injuries to the toes are very common. They may occur when the toes receive the impact of a heavy falling object, are stepped upon by another person or an animal, are run over by a wheel, or are caught in machinery or an automobile door. Automobile and truck wheels with rubber tires are less apt to cause such injuries than wagon and truck wheels with steel rims.

If the nail-bed is injured and there is hemorrhage under the nail, a hole should be drilled in the nail to allow the blood to drain out.

Wounds of soft tissues of the foot and ankle may be produced by physical or chemical trauma. Physical trauma includes cuts, blows, bruises, contusions, and the action of heat and cold. Wounds due to chemical trauma may be produced by any caustic agent. The prognosis depends upon the extent and depth of the wound and the presence or absence of complications such as infection, and bone, nerve, or tendon injury. In simple wounds through tissues which are not badly contaminated, primary suture may be successful if great care is taken to establish the integrity of the blood-vessels, nerves, and tendons before the skin is sutured.

In all cases of extensive wounds, roentgenograms should be made in two projections to determine the presence or absence of fracture or

dislocation. In large wounds which are actually or potentially contaminated, antitetanus serum should be used. If gas bacillus infection is likely, specific serum should be employed. Thorough surgical débridement followed by measures to keep the wound clean is more important than the specific type of treatment given.

After débridement, Orr inserts a petrolatum pack, leaves the wound open, and applies a plaster cast. Orr believes that it is not the primary infection which is most dangerous but infection favored by too frequent changing of the dressings. The method which found greatest favor during World War I was that known as the "Carrel-Dakin treatment," which consists of the insertion of Carrel rubber tubes and the instillation of Dakin's hypochlorite solution several times a day, usually every two or three hours. When this method is employed, numerous incisions for drainage are unnecessary.

Baer advised the use of living scavenger treatment by means of maggots. The Willems treatment of joint injuries and infections is immediate active mobilization. In extensive wounds, amputation may be necessary.

"Primary suture" means immediate suture of the wound. "Delayed primary suture" means that the wound is left open with sterile packing for from three to five days after débridement, and then sutured as a clean wound, layer by layer. If the wound is seen early and thoroughly débrided, it is permissible to apply sulfanilamide powder in the depths of the wound and close the wound in layers by primary suture.

The important natural agencies combating infection are the blood and tissue fluids and the leukocytes. The influence of the fluids is due to their alkalinity and their antitryptic power. The importance of the alkaline reaction of the fluids is demonstrated by the fact that the Welch bacillus grows better in serum from a patient with gas gangrene, a serum which has lost nearly all its alkalinity, than in normal serum.

CHAPTER XX

ESTIMATION OF FOOT AND ANKLE DISABILITY

DISABILITY is defined as the inability of a person to carry on his usual work temporarily, permanently, totally, or partially. There are several kinds of disability: temporary total, temporary partial, permanent total, permanent partial, and a cosmetic defect. Prolonged immobilization increases the period of temporary total disability and often leaves a permanent partial disability. It is important to start the injured person on light work as soon as possible. The causes of industrial deformities and disabilities are organic, functional, and a combination of the two.

The Functions of the Foot and Ankle are to	
Bear weight	Kick
Grasp the ground	Push objects
Balance	Touch
Stand	Feel
Walk	Propel
Run	Repel
Spring	Stop

One of the most vexing problems presented by the various compensation laws is the estimation of percentage of disability when permanent, irreparable damage has been done to a person by industrial injury. The final percentage of disability allowed is in the commissioner's hands. The value, therefore, of a standard whereby physicians can be uniform in their opinions concerning the percentage of disability resulting from a given type of deformity or loss of function is self-evident. Practically all tables of percentage of disability have been prepared by laymen.

The temporary total disability is the period of incapacity during the healing period. The permanent disability schedule of loss represents the probable average loss of earning capacity resulting from the effect of the permanent disability. Compensation for permanent partial disabilities should be expressed in percentages of permanent total disability.

The tables taken from McBride as given below are helpful in determining percentages of disability.

The Estimation of Disability of the Foot and Ankle Reduced to a Simple Mathematical Formula.—The following plan for estimating disability recognizes the function and biomechanics of the foot and ankle not only as a unit but also as a part of the entire body. All the subjective and objective elements are variable and reciprocal as to individual values. I have, therefore, for practical purposes, given each a decimal value.

Estimation of Disability should be based upon: deformity; discomfort; and disability.

AVERAGE NORMAL HEALING PERIOD IN TOTAL ANKYLOSIS OF THE ANKLE AND FOOT[1]

	Average immobilization or surgical care, weeks.	Average observation and treatment ended, weeks.	Able to begin work, weeks.
Following arthroplasty operation	12	20	10
Following arthrodesis operation	12	16	24
Following osteotomy operation	8	12	20
Following tenotomy	8	10	16
Following forcible stretching only . . .	10	16	24
Contusion or strain with synovitis .	1	2	2
Sprain approaching fracture severity . .	2	3	4
Contusion, strain or sprain complicating a weak arch	3	4	5
Dislocation	4	6	10
Fracture into joint	6	8	14
Scar tissue, plastic correction	10	12	16
Forcible manipulation and tenotomy . . .	5	6	8
Stiffness due to continuous immobilization .	4	8	10
Suppuration	16	20	36
Rheumatic disease	10	24	36

[1] McBride: Disability Evaluation, 2d ed., Philadelphia, J. B. Lippincott Company, 1939.

AVERAGE NORMAL HEALING PERIOD IN FRACTURES OF THE BONES OF THE FOOT[1]

	Approximate period immobilization or surgical care, weeks	Approximate end observation and treatment, weeks	Able to begin work, weeks
I. Fracture of the os calcis			
1. Transverse type: little displacement .	8	12	16
2. Oblique; incompletely reduced or comminuted	8	16	24
3. Oblique; well reduced	6	8	14
II. Fracture of the astragalus			
1. Fracture of neck with displacement .	8	12	24
2. Fracture of neck without displacement .	8	12	16
3. Chip fracture with sprain . .	6	[illegible]	[illegible]
III. Fracture of metatarsal . . .	4	7	[illegible]
IV. Fracture of the phalanges			
1. Great toe involving metatarsophalangeal joint	4	6	6
2. Other phalanges . .	2	4	[illegible]

[1] McBride: Disability Evaluation, 2d ed., Philadelphia, J. B. Lippincott Company, 1939.

Permanent Disability in Ankylosis of the Ankle and Foot

(Examples of approximate evaluations when percentage of loss is determined at the end of the healing period when the part can be used at work.)
Functions affected by the disability: balancing, lifting, twisting, turning, pivoting, pushing, springing, kicking, touching, pressing, rising, standing, stepping, walking, running, jumping.

100 per cent loss = *amputation or its equivalent*

Clinical factors contributing to disability	Quickness, alertness, speed, energy. Value 10%		Coördination, correlation, both legs and body. Value 20%		Strength, power, leverage. Value 20%		Security, reliability, confidence, control. Value 10%		Endurance, stability, tolerance. Value 20%		Safety as a workman. Value 10%		Prestige of physique, employment, chance of acceptance. Value 10%		Total value of part 100%
	Delayed action %	Loss	Awkwardness %	Loss	Weakness %	Loss	Insecurity %	Loss	Interruption %	Loss	Increased risk %	Loss	Adverse influence %	Loss	Per cent loss of foot
I Total ankylosis															
1 In angle of 90 degrees	55	5.5	65	13.0	35	7.0	40	4.0	35	7.0	25	2.5	25	2.5	41.5
2 In angle of 125 degrees	65	6.5	75	15.0	70	14.0	70	7.0	60	12.0	35	3.5	30	3.0	61.0
II Partial ankylosis															
A Flexion and extension motion limited to arc from 90 degree angle to															
1 105 degree plantar flexion	45	4.5	50	10.0	25	5.0	30	3.0	[illegible]	5.0	15	1.5	15	1.5	30.5
2 125 degree plantar flexion	20	2.0	25	5.0	15	3.0	10	1.0	15	3.0	10	1.0	5	0.5	15.5
B From 105 degree angle to															
1 125 degree plantar flexion	35	3.5	40	8.0	30	6.0	35	3.5	25	5.0	15	1.5	10	1.0	28.5
C From 115 degree angle to															
1 135 degree plantar flexion	65	6.5	75	15.0	70	14.0	70	7.0	60	12.0	35	3.5	25	2.5	60.5
III Adduction and abduction motion limited to arc															
A From 20 degree inversion and adduction to															
1 180 degree line	[illegible]	1.0	15	3.0	15	3.0	10	1.0	5	1.0	0	0.0	0	0.0	9.0
2 10 degree eversion and abduction	5	0.5	10	2.0	5	1.0	5	0.5	5	1.0	0	0.0	0	0.0	5.0
B From mid line to															
1 10 degree eversion and abduction	15	1.5	20	4.0	15	3.0	[illegible]	1.0	5	1.0	0	0.0	0	0.0	10.5
IV Fixed eversion deformity															
1 10 degrees	20	2.0	25	5.0	20	4.0	15	1.5	10	2.0	5	0.5	5	0.5	15.5
2 20 degrees	25	2.5	30	6.0	25	5.0	[illegible]	2.0	15	3.0	5	0.5	5	0.5	19.5
V Fixed inversion deformity															
1 10 degrees	10	1.0	15	3.0	10	2.0	15	1.5	15	3.0	5	0.5	5	0.5	11.5
2 20 degrees	15	1.5	20	4.0	15	3.0	20	2.0	20	4.0	5	0.5	5	0.5	15.5
3 30 degrees	25	2.5	30	6.0	25	5.0	30	3.0	30	6.0	10	1.0	10	1.0	24.5

NOTE.—To convert per cent loss of foot into per cent loss of leg *determine* the partial permanent loss of specific award value of the foot and divide the amount by the award value of the leg.

McBride: Disability Evaluation, 2d ed. Philadelphia: J. B. Lippincott Company, 1939.

The Estimation of Disability of the Foot and Ankle Reduced to a Simple Mathematical Formula.—The following plan for estimating disability recognizes the function and biomechanics of the foot and ankle not only as a unit but also as a part of the entire body. All the subjective and objective elements are variable and reciprocal as to individual values. I have, therefore, for practical purposes, given each a decimal value.

Estimation of Disability should be based upon: deformity; discomfort; and disability.

AVERAGE NORMAL HEALING PERIOD IN TOTAL ANKYLOSIS OF THE ANKLE AND FOOT[1]

	Average immobilization or surgical care, weeks	Average observation and treatment ended, weeks	Able to begin work, weeks
Following arthroplasty operation	12	20	40
Following arthrodesis operation	12	16	24
Following osteotomy operation	8	12	20
Following tenotomy	8	10	16
Following forcible stretching only	10	16	24
Contusion or strain with synovitis	1	2	2
Sprain approaching fracture severity	2	3	4
Contusion, strain or sprain complicating a weak arch	3	4	5
Dislocation	4	6	10
Fracture into joint	6	8	14
Scar tissue; plastic correction	10	12	16
Forcible manipulation and tenotomy	5	6	8
Stiffness due to continuous immobilization	4	8	10
Suppuration	16	20	36
Rheumatic disease	10	24	36

[1] McBride: Disability Evaluation, 2d ed., Philadelphia, J. B. Lippincott Company, 1939.

AVERAGE NORMAL HEALING PERIOD IN FRACTURES OF THE BONES OF THE FOOT[1]

	Approximate period immobilization or surgical care, weeks	Approximate end observation and treatment, weeks	Able to begin work, weeks
I. Fracture of the os calcis			
1. Transverse type: little displacement	8	12	16
2. Oblique; incompletely reduced or comminuted	8	16	24
3. Oblique; well reduced	6	8	16
II. Fracture of the astragalus			
1. Fracture of neck with displacement	8	12	24
2. Fracture of neck without displacement	8	12	16
3. Chip fracture with sprain	6	5	6
III. Fracture of metatarsal	4	7	[illegible]
IV. Fracture of the phalanges			
1. Great toe involving metatarsophalangeal joint	4	6	6
2. Other phalanges	2	4	[illegible]

[1] McBride: Disability Evaluation, 2d ed., Philadelphia, J. B. Lippincott Company, 1939.

PERMANENT DISABILITY IN ANKYLOSIS OF THE ANKLE AND FOOT[1]

(Examples of approximate evaluations when percentage of loss is determined at the end of the healing period when the part can be used at work.)
Functions affected by the disability: balancing, lifting, twisting, turning, pivoting, pushing, springing, kicking, touching, pressing, rising, standing, stepping, walking, running, jumping

100 per cent loss = amputation or its equivalent

Clinical factors contributing to disability	Quickness alertness speed energy — Value 10%		Coordination correlation both legs and body — Value 20%		Strength power leverage — Value 20%		Security reliability confidence control — Value 10%		Endurance stability tolerance — Value 20%		Safety as a workman — Value 10%		Prestige of physique employment chance of acceptance — Value 10%		Total value of part — 100%
	Delayed action %	Loss	Awkwardness %	Loss	Weakness %	Loss	Insecurity %	Loss	Interruption %	Loss	Increased risk %	Loss	Adverse influence %	Loss	Per cent loss of foot
I Total ankylosis															
1 In angle of 90 degrees	55	5.5	65	13.0	35	7.0	40	4.0	35	7.0	25	1.5	25	2.5	41.5
2 In angle of 125 degrees	65	6.5	75	15.0	70	14.0	70	7.0	60	12.0	35	3.5	30	3.0	61.0
II Partial ankylosis															
A Flexion and extension motion limited to arc from 90 degree angle to															
1 105 degree plantar flexion	45	4.5	50	10.0	25	5.0	30	3.0	25	5.0	15	2.5	15	1.5	30.5
2 125 degree plantar flexion	20	2.0	25	5.0	15	3.0	[illegible]	1.0	15	3.0	10	1.0	5	0.5	15.5
B From 105 degree angle to															
1 125 degree plantar flexion	35	3.5	40	8.0	30	6.0	35	3.5	25	5.0	15	1.5	10	1.0	28.5
C From 115 degree angle to															
1 135 degree plantar flexion	65	6.5	75	15.0	70	14.0	70	7.0	60	12.0	35	3.5	25	2.5	60.5
III Adduction and abduction motion limited to arc															
A From 20 degree inversion and adduction to															
1 180 degree line	10	1.0	15	3.0	15	3.0	10	1.0	5	1.0	0	0.0	0	0.0	9.0
2 10 degree eversion and abduction	5	0.5	10	2.0	5	1.0	5	0.5	5	1.0	0	0.0	0	0.0	5.0
B From mid line to															
1 10 degree eversion and abduction	15	1.5	20	4.0	15	3.0	10	1.0	5	1.0	0	0.0	0	0.0	10.5
IV Fixed eversion deformity															
1 10 degrees	20	2.0	25	5.0	20	4.0	15	1.5	10	2.0	5	0.5	5	0.5	15.5
2 20 degrees	25	2.5	30	6.0	25	5.0	20	2.0	15	3.0	5	0.5	5	0.5	19.5
V Fixed inversion deformity															
1 10 degrees	10	1.0	15	3.0	[illegible]	2.0	15	1.5	15	3.0	5	0.5	5	0.5	11.5
2 20 degrees	15	1.5	20	4.0	15	3.0	[illegible]	2.0	20	4.0	5	0.5	5	0.5	15.5
3 30 degrees	25	2.5	30	6.0	25	5.0	30	3.0	30	6.0	10	1.0	10	1.0	24.5

NOTE.—To convert per cent loss of foot into per cent loss of leg determine the partial permanent loss of specific award value of the foot and divide the amount by the award value of the leg.

[1] McBride: Disability Evaluation, 2d ed. Philadelphia, J. B. Lippincott Company, 1939.

Permanent Disability in Fractures of the Foot[1]

(Examples of approximate evaluations when percentage of loss is determined at the end of the healing period and the part can be used at work.)

Functions affected by the disability: balancing, twisting, turning, pivoting, pushing, springing, pressing, rising, touching; activities as standing, stepping, running, jumping, walking, kicking, throwing

100 per cent loss = amputation or its equivalent

Causal factors contributing to disability (exclusive of ankylosis)	Quickness, nimbleness, agility, speed. Value 10%. Delayed union, %	Loss	Coordination, correlation both legs and body. Value 20%. Awkwardness, %	Loss	Strength, power, leverage. Value 20%. Weakness, %	Loss	Security, reliability, control. Value 10%. Insecurity, %	Loss	Endurance, toleration, stability. Value 20%. Fatigue more quickly, %	Loss	Safety as a workman. Value 10%. Increased risk, %	Loss	Prestige of physique; employment, chance of acceptance. Value 10%. Adverse influence, %	Loss	Total value of part 100%. Loss to foot
[illegible] Malunion [illegible]	25	2.5	30	6.0	20	4.0	40	4.0	25	5.0	15	1.5	25	2.5	25.5
[illegible] united, fair reduction [illegible]	20	2.0	25	5.0	15	3.0	30	3.0	20	4.0	15	1.5	20	2.0	20.5
[illegible] astragalus [illegible]	20	2.0	25	5.0	15	3.0	30	3.0	25	5.0	15	1.5	15	1.5	21.0
[illegible]	15	1.5	20	4.0	10	2.0	20	2.0	15	3.0	10	1.0	10	1.0	14.5
[illegible] tarsal bones, [illegible]	10	1.0	15	3.0	10	2.0	10	1.0	10	2.0	5	0.5	10	1.0	10.5
[illegible]	5	0.5	10	2.0	10	2.0	10	1.0	10	2.0	5	0.5	10	1.0	9.0
[illegible]	5	0.5	5	1.0	0	0.0	5	0.5	5	1.0	0	0.0	5	0.5	3.5
[illegible]	10	1.0	10	2.0	5	1.0	10	1.0	10	2.0	5	0.5	10	1.0	8.5

Note. — [illegible] per cent loss of [illegible] partial permanent loss of [illegible]

[1] McBride, E. D.: [illegible] 2nd ed., Philadelphia, J. B. Lippincott Company, 19[illegible]

Lewin's Estimation of Disability of the Foot and Ankle

	Components	Unit value	% of loss of unit value	Remainder
1	PAIN	10%		
2	DEFORMITY	10%		
3	DISABILITY—LIMP	10%		
4	OCCUPATION INDEX	10%		
5	REEMPLOYMENT INDEX	10%		
6	RECURRENCE INDEX	10%		
7	EFFECT ON OTHER PARTS OF THE BODY	10%		
8	PSYCHOSOMATIC EFFECT	10%		
9	BEHAVIOR CHARACTERISTICS	10%		
10	MISCELLANEOUS FACTORS	10%		
	TOTAL	100%		
	DISABILITY			

1 *Pain*
- during
  - day
  - night
- during activity at
  - work
  - play

2 *Deformity*
- appearance—posture
  - primary
  - secondary

3 Disability
- function
  - alertness
  - coordination
  - strength
  - endurance
    - at work
    - at play
    - at home

4 Occupation Index (previous occupation)

5 Reemployment Index
- person's previous occupation
- a new occupation
- reduction of wages
- reduction of desirability

6 Recurrence Index
- real
- imaginary
- insurance index

7 Effect on Other Parts of the Body
- physical
- mental

Permanent Disability in Fractures of the Foot[1]

(Examples of approximate evaluations when percentage of loss is determined at the end of the healing period and the part can be used at work.)
Functions affected by the disability. balancing, twisting, turning, pivoting, pushing, springing, pressing, rising, touching; activities as standing, stepping, running, jumping, walking, kicking, throwing.

100 per cent loss = amputation or its equivalent

Clinical factors contributing to disability (exclusive of ankylosis).	Quickness, nimbleness, agility, speed. Value 10%		Coordination, correlation both legs and body. Value 20%		Strength, power, leverage. Value 20%		Security, reliability, control. Value 10%.		Endurance, toleration, stability. Value 20%		Safety as a workman. Value 10%.		Prestige of physique, employment, chance of acceptance. Value 10%.		Total value of part 100%.
	Delayed union, %.	Loss.	Awkwardness %	Loss	Weakness, %.	Loss	Insecurity, %	Loss	Fatigue more quickly, %	Loss	Increased risk, %.	Loss	Adverse influence, %.	Loss.	Loss to foot.
A Tarsal bones															
1. Fracture of os calcis:															
(a) Malunion	25	2.5	30	6.0	20	4.0	40	4.0	25	5.0	15	1.5	25	2.5	25.5
(b) Comminuted, fair reduction	20	2.0	25	5.0	15	3.0	30	3.0	20	4.0	15	1.5	20	2.0	20.5
(c) Arthrodesis															
2. Fracture of astragalus:															
(a) Malunion	20	2.0	25	5.0	15	3.0	30	3.0	25	5.0	15	1.5	15	1.5	21.0
(b) Severe fracture, good alignment	15	1.5	20	4.0	10	2.0	20	2.0	15	3.0	10	1.0	10	1.0	14.5
3. Fracture of other tarsal bones:															
(a) Malunion	10	1.0	15	3.0	10	2.0	10	1.0	10	2.0	5	0.5	10	1.0	10.5
(b) Arthrodesis	5	0.5	10	2.0	10	2.0	10	1.0	10	2.0	5	0.5	10	1.0	9.0
B. Metatarsals															
1 10 degree angulation, prominent head	5	0.5	5	1.0	0	0.0	5	0.5	5	1.0	0	0.0	5	0.5	3.5
2 20 degree angulation prominent head	10	1.0	10	2.0	5	1.0	10	1.0	10	2.0	5	0.5	10	1.0	8.5

Note.—To convert per cent loss of foot into per cent loss of leg, determine the partial permanent loss of specific award value of the foot and divide by specific award value of leg.

[1] McBride Disability Evaluation, 2d ed., Philadelphia, J B. Lippincott Company, 1939.

Lewin's Estimation of Disability of the Foot and Ankle

	Components	Unit value	% of loss of unit value	Remainder
1	Pain	10%		
2	Deformity	10%		
3	Disability—Limp	10%		
4	Occupation Index	10%		
5	Reemployment Index	10%		
6	Recurrence Index	10%		
7	Effect on Other Parts of the Body	10%		
8	Psychosomatic Effect	10%		
9	Behavior Characteristics	10%		
10	Miscellaneous Factors	10%		
	Total	100%		
	Disability			

1 *Pain*
- during
  - day
  - night
- during activity at
  - work
  - play

2 *Deformity*
- appearance—posture
  - primary
  - secondary

3 Disability
- function
  - alertness
  - coordination
  - strength
  - endurance
    - at work
    - at play
    - at home

4 Occupation Index (previous occupation)

5 Reemployment Index
- person in previous occupation
- in new occupation
- reduction of wages
- reduction of desirability

6 Recurrence Index
- real
- imaginary
- insurance index

7 Effect on Other Parts of the Body
- physical
- mental

8. Psychosomatic Effect
- fear
- inferiority complex
- security
- risk of future injury

---

9. Behavior Characteristics, attributable to Foot and Ankle Disorders
- impression on other people
  - real
  - imaginary
- effect on happiness of person
  - athletics
  - amusements
- effect on his household

---

10. Miscellaneous Factors
- impression on examiner

CHAPTER XXI

MILITARY ASPECTS OF FOOT AND ANKLE DISORDERS*

Introduction.—My army experience in the United States, England and France, during World War I gave me considerable insight into the causes and treatment of many conditions which occur in and around the foot and ankle that are peculiar to the military services

During one assignment at Camp Grant,† I measured and examined the feet of 5,000 soldiers In LeMans, France, for three months, I had charge of 24 military shoe fitters who were able to fit about 500 pairs of feet per hour

Some important concepts regarding the soldier's foot and ankle were gained from experience in World Wars I and II

Foot and ankle conditions occurring in the military services are in many respects different from those found in civilian life Many diverse factors must be recognized if success is to be achieved These vary from the accurate diagnosis of mild static deformities to the proper shoeing and adaptation of each foot to its particular military duty This duty may be in the Infantry, Navy, Marine Corps, Air Service, Paratroop and Mountain Services, Nursing Corps, Red Cross or the many associated services

War Injuries of the Foot and Ankle

Causes	Types of Injuries
Projectiles	Crushing
Crushing injuries	*Infection*
Sniper bullets	Fractures
Anti-personnel mines	Dislocations
Blast injuries	Blood-vessel injuries
Bomb fragments	Nerve injuries
Flak from airplanes	
Mountain troops	

* In World War I I was chief of the orthopædic division at Camp Grant and Camp Taylor In England as a member of The Royal Army Medical Corps I served at the Third Western General Hospital in Newport Monmouthshire In France I served at Chaumont Chateauroux Le Mans Angers Savenay and Paris In World War II I was Chief of Surgery and Chief of Orthopedic Surgery of the 16th Evacuation Hospital an observer at Percy Jones General Hospital and Chief of the Orthopedic Services at Gardiner and Mayo General Hospitals

† An illustrative incident occurred at Camp Grant early in October 1917 About 200 colored soldiers were on sick call at the base hospital After asking about 20 men what was wrong and each replied Flat feet the medical officer shouted Attention and proceeded to deliver a lecture on the frequency of flat feet in normal colored men Then he asked another group of 20 men Now what is wrong? whereupon each one answered Nothing sir The officer then called out Fall out and return to your organizations

8. Psychosomatic Effect { fear / inferiority complex / security / risk of future injury

---

9. Behavior Characteristics, attributable to Foot and Ankle Disorders

impression on other people { real / imaginary

effect on happiness of person { athletics / amusements

effect on his household

---

10. Miscellaneous Factors

impression on examiner

CHAPTER XXI

MILITARY ASPECTS OF FOOT AND ANKLE DISORDERS*

Introduction—My army experience in the United States, England and France, during World War I gave me considerable insight into the causes and treatment of many conditions which occur in and around the foot and ankle that are peculiar to the military services

During one assignment at Camp Grant,† I measured and examined the feet of 5,000 soldiers In LeMans, France, for three months, I had charge of 24 military shoe fitters who were able to fit about 500 pairs of feet per hour

Some important concepts regarding the soldier's foot and ankle were gained from experience in World Wars I and II

Foot and ankle conditions occurring in the military services are in many respects different from those found in civilian life Many diverse factors must be recognized if success is to be achieved These vary from the accurate diagnosis of mild static deformities to the proper shoeing and adaptation of each foot to its particular military duty This duty may be in the Infantry, Navy, Marine Corps, Air Service, Paratroop and Mountain Services, Nursing Corps, Red Cross or the many associated services

War Injuries of the Foot and Ankle

Causes	Types of Injuries
Projectiles	Crushing
Crushing injuries	Infection
Sniper bullets	Fractures
Anti-personnel mines	Dislocations
Blast injuries	Blood-vessel injuries
Bomb fragments	Nerve injuries
Flak from airplanes	
Mountain troops	

* In World War I I was chief of the orthopædic division at Camp Grant and Camp Taylor In England as a member of The Royal Army Medical Corps I served at the Third Western General Hospital in Newport Monmouthshire In France I served at Chaumont Chateauroux Le Mans Angers Savenay and Paris In World War II I was Chief of Surgery and Chief of Orthopedic Surgery of the 18th Evacuation Hospital an observer at Percy Jones General Hospital and Chief of the Orthopedic Services at Gardiner and Mayo General Hospitals

† An illustrative incident occurred at Camp Grant early in October 1917 About 200 colored soldiers were on sick call at the base hospital After asking about 20 men what was wrong and each replied Flat feet the medical officer shouted Attention and proceeded to deliver a lecture on the frequency of flat feet in normal colored men Then he asked another group of 20 men Now what is wrong? whereupon each one answered Nothing sir The officer then called out Fall out and return to your organizations

War Injuries to the Feet.—War injuries to the feet are usually due to:

1. Projectiles.
2. Crushing accidents.

Special rules for the foot and ankle:

1. There must be no pocketing of pus.
2. Alignment is most important.
3. Never immobilize in the position of maximum correction.

The resulting deformities, disabilities and death from modern war wounds has been greatly reduced by means of the mobile surgical operating rooms contained in automobile trailers. The mobile roentgen-ray and anesthesia units have increased the outlook for the wounded soldier very materially.

TRANSPORTATION OF INJURED AND WOUNDED

World War II proved the value of rapid evacuation and transportation of seriously wounded soldiers. Men were transported long distances by fast boats and airplanes. The wounded were given excellent surgical care during transit. In most cases the continuity of treatment was maintained. Immobilization of badly fractured limbs was maintained. Pain was controlled. Local alignment was not disturbed and infection was combated to a remarkable degree.

MODERN WARFARE AND ITS EFFECTS ON INJURIES OF THE FOOT AND ANKLE

The mechanization of war with its increased mobility presented new problems in the collection and transportation of the wounded. The increasing range of artillery fire combined with mobility of the front and the ubiquity of the airplane decreased in type and amount the surgery permissible at the front. Many more feet and ankles were saved during World War II, that would have been lost in previous campaigns.

Many factors are responsible for this advance, especially,

1. Immediate Surgery.
2. Better surgery.
3. Improved treatment of shock and hemorrhage, especially blood and blood substitutes.
4. Chemotherapy—especially penicillin.
5. Better transportation:
   of wounded personnel
   of materials.
6. Better continuity of treatment
7. Better treatment of peripheral vascular lesions.
8. Better treatment of sympathetic nerve disorders.

We saved more patients who had
1 Hemorrhage
2 Shock
3 Crushing injuries
4 Vascular injuries
5 Nerve injuries
6 Osteomyelitis

In the latter two-thirds of World War II, penicillin was undoubtedly responsible for the improvement in the results of treatment of battle casualties (The Sulfas were largely replaced by penicillin during the early part of 1944)

Parachute Injuries —The study of Barnett and Lewin based on 450 injuries suffered by parachute troops undergoing basic training reveals that the training is very severe and attended by many and varied injuries

Foot and Ankle Injuries in Mountain Troops —Mountain troops are subjected to great stress and strain of the feet, especially during their rigid training for combat Injuries are frequent and severe

Blast Injuries —This classification comprised a new type of injury so far as mass production is concerned

The chief causes of blast injuries were high explosive bombings on on land, in the air, on the sea, and below the surface of the water Although at first the injuries appeared to be trivial, serious effects were the rule

Example —A person on deck of a ship that is torpedoed He is thrown upward When he comes down very forcibly and strikes the hard deck which was forced down and then up, he is apt to suffer serious injuries to his tibia and fibula, ankle and foot

TREATMENT OF WOUNDS TO SOFT TISSUES OF THE FOOT AND ANKLE

Experience on the battlefields of World War II indicates that infection was a far less serious problem than in World War I The wounded soldiers were less fatigued and dehydrated, their clothes were cleaner, many of the weapons were less damaging to the tissues than the shell and hand grenades which were used so much in World War I Most army surgeons agree that much credit must go to good surgery, blood transfusions and chemotherapy

The lacerating, destructive type of wound is the one most concerned in the surgical treatment in modern warfare

Careful, deliberate debridement is still the outstanding important treatment of wounds Regardless of what other measures are used, none will succeed if débridement is not complete Ogilvie divides the

progress of wound infection into two stages, *viz.*, contamination and infection.

In the first stage, bacteria which have been carried in by the causative agent lie on the surface of the wound, in bits of dirt, mud, grease, clothing or metal fragments, or in the blood clot. This is the stage in which bacteria can be removed by thorough mechanical cleansing. During the second stage, the bacteria, taking advantage of the supply of the culture medium available to them in the dead matter, blood-clot, lymph and damaged muscle, have multiplied and started to invade the host. For practical purposes the stage of contamination may be looked upon as lasting twelve hours before it passes into that of infection. When the organisms are few, the available culture medium scanty, and the surrounding tissues healthy, the state of the patient's skin and clothes and the appearance of the wound will aid in the estimation of the probable degree of infection.

The treatment of war wounds may be divided into two categories, (*a*) those seen early, and (*b*) those seen late. In this section the discussion will be limited to wounds of soft tissues of the foot and ankle.

Early Treatment.—The principles of cleansing and débridement still hold, but the method has become altered somewhat, and new principles have been introduced. Excision of contaminated war wounds at the earliest opportunity, after careful cleansing with soap and water, is a most valuable prophylactic measure. Chemical antiseptics have been discarded for the most part.

Chemotherapy.—The local application, directly into a wound, of sulfanilamide crystals or powder has done much to prevent severe streptococcal infections. Chemoprophylaxis when started early puts the patients in good condition, while those infected at the time of arrival at the hospital, in whom chemotherapy was started immediately after débridement, soon show repair and clean granulation. There is a marked contrast between wounds of those who had received a sulfonamide derivative in transit and those who had not. The latter, when admitted two or three days after being wounded, were most seriously infected.

Sulfanilamide should be given by mouth as well as applied locally in most cases. Although it is difficult in wartime to follow the blood reaction to the drug, it is usually not necessary to administer the drug for more than three or four days, thus obviating many of its ill-effects. The "golden period" from time of injury to time of treatment was considered as six hours in World War I. However, now this period can be prolonged to perhaps twenty-four or forty-eight hours provided chemoprophylaxis has been instituted.

At Great Lakes Naval Hospital good results were obtained by the following measures:

In addition to penicillin parenterally, tyrothrycin locally 1 to 60 as an irrigation vehicle or as a gauze-soaked pack is administered

Furacil ointment is valuable in sterilizing many superficial infected wounds such as those over infected amputation ends It is used

I Locally and

II Parenterally

Streptomycin is of value in infections with gram negative organisms

When the sulfa drugs appeared they were used in almost every condition involving wounds of the foot and ankle

It made little difference whether the wounds were produced by ordinary industrial or civilian trauma or by the surgeon in the operating room It was a great source of comfort to the surgeon to use the sulfas and feel that no infection would occur if none had been present previously

Then when penicillin appeared it was thought that we had made assurance doubly sure of curing an infection or preventing an infection Therefore the surgeon used the sulfas locally in the wound and penicillin parenterally However, experience did not bear out this theory and before long an order came from the Surgeon General of the Army prohibiting the combined use of these drugs

Streptomycin inhibits the growth of several species of gram positive, gram negative and acid fast organisms

Furacin is recommended for impetigo-like infections especially around wounds and amputation stumps

Thomson's work on Local Wound or Tissue shock and the value of sympathetic nerve blocks is very important

The best available early treatment for the prevention of serious infections and gas gangrene, in addition to surgery, is the combination of antitoxin and chemotherapy

Every soldier is inoculated with tetanus toxoid as a prophylactic measure against the development of tetanus

In early cases in which adequate cleansing and débridement can be carried out and chemotherapy applied, primary closure of the wound can be attempted with widely placed interrupted sutures The number of wounds which heal by primary union, even after gross contamination, is surprising If it is possible to "débride" sufficiently, and the wound is treated early, it is thoroughly acceptable to attempt suture of tendons, provided the principles of tendon suturing are followed and even to close the skin loosely over such wounds

However, if there is the least suspicion of burying infection the wound should be left wide open and dressed loosely with vaseline gauze, or gauze soaked in azochloramide The latter dressings must be changed rather frequently Even if there are no fractures the foot and ankle should be splinted to prevent contractures

Colebrook estimates that streptococci are responsible for at least 70 per cent of all deaths due to infection of wounds. Of 49 positive blood cultures, 44 were hemolytic streptococci. Fifteen per cent of all cultures from wounds *reveal streptococci* within twelve hours and in a few days the percentage is much larger—up to 90 per cent. It seems, therefore, that if chemotherapy is active at the time the organism reaches the tissue an infection might be prevented. Colebrook advised that since a single prophylactic dose is excreted in ten to twenty hours, the following dosage is advocated:

First dose: 1.5 grams dissolved in 100 cc. of 1 per cent hot citric acid solution or hot lemon juice.

Second dose: 0.5 gram without dissolving to delay absorption, two hours later.

Subsequent doses: 0.5 gram at four-hour intervals for four days. Total dose 13.5 grams in four days.

Colebrook also states that sulfapyridine is more effective in gas gangrene than sulfanilamide. The danger of granulocytopenia in the use of either drug must be kept in mind.

DÉBRIDEMENT

Débridement means the removal of tissue that is irreparably damaged. There has been some criticism of the term. However, it has stood the test of time and experience. The term "wound toilet" has been suggested.

In performing débridement, great care and much experience is required. The future of the limb, or even life, may depend upon the débridement.

Very often large sections of bone and soft tissues should be removed.

During World War I, Leriche coined the word "Esquillectomy" which means removal of bone that has been irreparably damaged or deprived of blood supply. His dictum was "tout vaux mieux que l'infection." (Anything is better than infection.)

There is no doubt many cases o non-union followed large bone defects.

In the foot the most serious location for large defects is in the big toe, because of the danger of "dangle toe."

Locally, early débridement and irrigation are recommended. During World War I Dakin's solution was very effective. This has been supplanted by penicillin, by irrigation, and implantation.

One must be on guard to combat lymphatic transmission of infection. The inguinal lymph nodes are indicators of spread of infection from the foot.

Delayed Closure —Delayed closure is recommended in wounds that are more than twelve hours old In the presence of obvious infection, they are thoroughly opened and irrigated with Dakin's solution Electrosurgical apparatus is advocated because the current destroys bacteria, bleeding is reduced, and postoperative shock is minimal, presumably due to severed nerve ends and reduction in loss of blood It is also suggested that roentgen-ray units be incorporated in the equipment of mobile surgical and evacuation hospitals for therapeutic use in all potentially dirty wounds However, evidence is still controversial that the prophylactic use of roentgen-rays is beneficial as an adjunct to thorough débridement Sulfanilamide derivatives were used in wounds as a prophylactic measure

Injury to Blood-Vessels —Injury to blood-vessels of the foot and ankle is not as serious as it may be in some other parts of the body Because of the anastomotic arrangement between the branches of the anterior tibial, posterior tibial and peroneal arteries, it is possible to maintain collateral circulation after one or the other of these arteries has been severed Blood-vessel repair at an evacuation hospital in a potentially dirty wound is extremely difficult and if the ends of a severed artery cannot be isolated and brought together with ease, the best policy is to ligate them and watch the circulatory status of the foot very carefully

There are reports of repair of a defect in the femoral artery by the transplant of a portion of the jugular vein The method consists essentially of using a blunt clamp on either end of the defect, cleaning the end of the artery, removing a portion of jugular vein and transplanting it into the arterial defect Thrombosis is obviated by the injection of heparin or dicoumerol

PENETRATING AND PERFORATING WOUNDS OF THE FOOT AND ANKLE

Penetrating wounds are caused by foreign substances which go clear through from skin through skin Perforating wounds are caused by foreign substances which enter the foot but do not go through These substances may be steel, aluminum, lead, glass, wood or fabric

The tissues affected by penetrating wounds are

1 Bone
2 Joint
3 Synovia
4 Ligaments
5 Bursa
6 Nerves
7 Vessels

Among the most serious results are infection of soft tissue, osteomyelitis, aneurysm, and neuroma Pocketing of infected material is

harmful because of absorption and continued infection. This requires drainage preferably in a dependent area.

Active mobilization is advisable unless bones are fractured.

CRUSHING INJURIES

Treatment of crushing injuries includes the following measures:

Conservative	Biological
Surgical	Protective
Chemotherapy	Supportive

One should combat infection that is present or imminent. He should restore normal appearance and relationships of architecture. The soft tissues usually fall into line.

Remarkable results usually follow the following routine.

1. Anesthesia.
2. Mold the foot into normal alignment so that it looks like the other foot and bears normal relations to ankle and leg.
3. Support and protect.

Here is one instance where you can truthfully say: "Ain't nature grand?"

Operative Procedures in Crushing Injuries of the Foot and Ankle.—The usual sequence is as follows:

1. Excision of avascular tissue.
2. Blood supply—is the *sine quo non.* Without adequate blood supply all plastic surgery will be futile.
3. Skin covering. Skin is not expendable.
4. Nerves.
5. Bones.
6. Tendons.
7. Muscles.

Immobilization:

1. Immobilize the wound.
2. The limb.
3. The patient.
4. Cast in neutral position.
5. Split immediately.
6. Beware of constricting bandages under cast.

Foreign Bodies in the Foot and Ankle.—Foreign bodies should be searched for with diligence in the depths of every wound before débridement is considered complete. Localization of foreign bodies by means of fluoroscopy or roentgen-ray is of great assistance. If a foreign body is located deep in a wound, all the tissues surrounding that region should be carefully débrided and if the wound was grossly dirty, it should be left open for drainage. Bullets should not be left

in the depths of wounds, even if a later operation has to be done to remove them (Lead poisoning has been known to result from bullets embedded in tissues for several years)

Foreign bodies may be radiopaque or radiolucent The former includes

Ceramic objects and biological material such as encrusted or encysted animals may be radiopaque Wood is radiolucent

Metallic foreign bodies include

1 Needles
2 Pins
3 Missiles such as buckshot, bullets and shell fragments
4 Glass (if it contains lead)

The superstition regarding extensive migration of foreign bodies from the sole of the foot to the heart is fantastic and ridiculous

There is considerable danger of infection The best example is stepping on a rusty nail and developing tetanus Blood-vessel injury may produce aneurysm Nerve injury may cause paralysis or a neuroma

SELECTIVE SERVICE—PHYSICAL STANDARDS FOR THE FOOT AND ANKLE

The regulations contained in Volume Six of Physical Standards were prescribed by executive order of President F D Roosevelt on October 18, 1940

Standards are set forth for the selection of registrants for active service in the United States Army or Navy Those requirements referable to the foot and ankle are as follows

Class 1a —(Those registrants considered fit for general military service)

A Normal lower extremities with normal function

B Old or recent fractures which have healed spontaneously with no resulting impairment of function

C Paralysis of a muscle or group of muscles, not interfering with function

D Benign tumors of bone, or defects due to their removal when the condition does not interfere with the function of an extremity or joint involved

E Recent injury of a bone or joint with or without fracture or dislocation, which, in the opinion of the examiners, is only temporarily incapacitating

F Web toes, unless severe in degree

G Pes planus unless accompanied by marked deformity, rigidity or weakness, or of such degree as to have interfered with useful function in civil life

H. Hallux valgus unless severe.
I. Club-foot of slight degree if tarsal, metatarsal and phalangeal joints are flexible and the condition permits the wearing of a military shoe and, in the opinion of the examiner, will not interfere with the performance of military duty.
J. Slight claw-toes not involving obliteration of the transverse arch and which do not interfere with the wearing of a military shoe.
K. Hammer toe which is flexible and which does not interfere with the wearing of a military shoe.
L. Absence of one or two of the small toes of one or both feet, if function is good.
M. Ingrowing toenails.

Class Ib—(Those registrants fit only for limited military service.)
A. Internal derangement of the knee joint if not severe enough to have prevented him from following a useful vocation in civil life.
B. Abduction and pronation (knock-ankle) when this condition is not associated with rigidity of the tarsal joints or with deformity of the foot.
C. Loss of the great toe.
D. Loss of the dorsal flexion of the great toe.
E. Hammer toe with rigidity.
F. Other defects of the foot which disqualify for general military service but do not prevent the registrant from wearing military shoes, and which have not prevented him from following a useful vocation in civil life.
G. Moderate deformities of one or both lower extremities which do not and have not interfered with the function to a degree to prevent the registrant from following a useful vocation in civil life.
H. Adherent scars of the skin and soft tissues of an extremity.
I. Ununited fractures which do not interfere with good function
J. Benign tumors of bone or joint which do not interfere with function.
K. Other defects which, in the opinion of the examining physician, are disqualifying but remediable, but which have not prevented the registrant from following a useful vocation in civil life.
L. Thrombophlebitis of one or more extremities if there is persistent thrombus or any evidence of obstruction of circulation in the involved vein or veins.

M Other abnormalities of the peripheral vascular system, including large varicose veins, Raynaud's disease, Buerger's disease (thrombo-angiitis obliterans), erythromelalgia, and arteriosclerosis of the leg vessels (In doubtful cases, special tests should be employed)

CLASS 4—(Those registrants physically unfit for general military service)

A Chronic inflammatory disease of long duration of one or more of the large joints, with or without sinuses

B Tuberculosis of bone or joint (The diagnosis should be based upon presence of swelling, tenderness, muscular spasm, restriction of joint motion and evidence of bone destruction shown by roentgen-ray)

C Old ununited fractures which interfere with function or ununited fractures with deformity sufficient to interfere with function

D Old unreduced dislocations which have interfered with the registrants following a useful vocation in civil life

E Diseases of any bone or joint healed with such resulting deformity or rigidity that the function is impaired to a degree that will interfere with military service

F Muscle paralysis or contraction which disturbs function to the degree of interference with military service

G Adherent scars of skin or soft tissue to a degree which seriously interferes with function

H Varicose veins, if severe in degree, or if associated with edema or ulcer of the skin

I Pes planus, if accompanied by marked deformity, rigidity, or weakness, or of such degree as to have interfered with useful vocation in civil life

J Obliteration of the transverse arch associated with permanent flexion of the small toes (claw-toes)

K Hallux valgus if severe and associated with marked exostosis or bunion, especially when there are signs of irritation above the joint

L Club-foot, if marked in degree or which interferes with the wearing of a military shoe

M Diseases of the bones or of the hip, knee or ankle joints which seriously interfere with function and weight-bearing power

N Deformities due to fracture or other injury which seriously interfere with function and weight-bearing power

O Sciatica which is apparently intractable and disabling to the degree of interfering with the function of walking and weight-bearing power

P. Amputations of extremities in excess of those already cited

General Remarks.—It is important that registrants with defects of the feet which are not remediable by training and which prevent the inducted men from taking proper military training should not be accepted for general military service. It is quite as important that defects of the feet which are not disabling should not be considered disqualifying for general military service.

Col. L. G. Rowntree recently announced that foot ailments were responsible for the rejection of 4 per cent of draftees and 6 per cent of those already inducted into the Army.

Nerve Injuries.—The treatment of nerve injuries of the foot and ankle concerns itself mainly with severance of the anterior tibial nerve, the peroneal nerve, and the tibial (internal popliteal) nerve. When these are found severed, an attempt at repair should be made, provided the injury is fresh. In an infected wound nerve suture is futile and dangerous. Later tendon transplantation can be done to compensate for nerve injuries, or the severed ends can be dissected from scar tissue and the ends cleaned and sutured.

Later Treatment.—The condition in which prophylactic use of a sulfonamide was valuable was a late wound, twenty-four or forty-eight hours or perhaps a week after infection, requiring operation and suggesting the possibility of a flareup. If a full dose was given by mouth beforehand, intervention was safer. A few doses would on most occasions deal with an acute streptococcic infection, but not with a chronic one. When the infection was in the blood the drug was not of the same value as when it was in the body tissues. The same held true for gas gangrene.

A sulfonamide derivative is valuable in a case of secondary operation in which there was a suspicion of hemolytic streptococcus infection. Prophylactic treatment should be administered in four hourly doses. In long-standing or superficial cases, such as old burns and road accidents which led to infection, the application of sulfanilamide powder gave astonishingly good results. Where the drug cannot be taken by mouth, the soluble sodium salt (sodium sulfapyridine) may be used.

When injured men come under observation at a late period when the organisms of gas gangrene have already reached the living tissue bordering on the wound cavity or when the wound is passing through a stage of physiological reaction to injury, the time for prophylactic excision has passed and the surgeon must aim at providing adequate drainage by incision. In late cases, however, in which there is any suspicion of gangrenous infection of muscle, the wound must be opened up and the muscles affected must be extensively excised.

The best available treatment for the established case of gas gangrene, in addition to surgery, is a combination of antitoxin and chemo-

therapy The serum and drug seem to have a synergic action, the former neutralizing the bacterial toxin, while the latter exercises a bacteriostatic effect on the organism The antitoxin should be administered, preferably intravenously, at the earliest possible moment

Many serious *contractures* of the foot and ankle can be prevented if the foot is kept in proper position during the period of treatment A simple posterior molded splint made of almost any rigid material will suffice If the foot is kept at a right angle to the leg with the toes pointing to the ceiling and in direct line with the patella, it will be possible to start active motion earlier and it will be accompanied by less pain These principles hold true in crushing or severe soft tissue injuries to the leg, foot and ankle, regardless of bony involvement

With the mechanization of modern warfare, the type of injury to the foot and ankle has become much more severe The injuries today are of a severe crushing type, being caused by high explosives, or being run over by heavy mechanized army equipment With such ripping and tearing injuries, the tissues have a wider area which will be contused and abraded, and hence must be debrided widely

Tetanus antitoxin and gas bacillus serum should be given routinely to every patient with a severe injury of the foot and ankle, regardless of what surgery or chemotherapy is instituted

Amputation for soft tissue injuries of the lower leg becomes necessary only when there is complete devitalization of the part, with impending spread of gangrene Amputations for gangrene and gas gangrene should be well above the area of involvement

Factors in Wound Healing (Mason) —1 *Blood Supply* —Tight sutures and tight bandages may render portions of tissue avascular and result in local necrosis Following closure of a wound, vascular stasis, edema and hemorrhage may also cause local circulatory disturbances The venous return of the leg is often markedly improved by slight elevation Support by a firm, semi-elastic, but not tight bandage prevents serum from accumulating

2 *Irritants* of various sorts lower tissue vitality and may even bring healing to a standstill These irritants include antiseptic drugs and chemicals Recent experiments have shown that when sulfanilamide or its allied compounds are used locally in excess, delay in healing may result

3 *Mechanical or chemically inert irritants*, such as foreign bodies, may carry infecting organisms into a wound, or their presence may interfere with healing The surgeon should put into the wound the least amount of foreign material compatible with a satisfactory repair The present trend is toward the use of fine silk, steel or cotton in clean wounds Only the finest catgut which will hold the tissues properly apposed should be used

P. Amputations of extremities in excess of those already cited.

General Remarks.—It is important that registrants with defects of the feet which are not remediable by training and which prevent the inducted men from taking proper military training should not be accepted for general military service. It is quite as important that defects of the feet which are not disabling should not be considered disqualifying for general military service.

Col. L. G. Rowntree recently announced that foot ailments were responsible for the rejection of 4 per cent of draftees and 6 per cent of those already inducted into the Army.

Nerve Injuries.—The treatment of nerve injuries of the foot and ankle concerns itself mainly with severance of the anterior tibial nerve, the peroneal nerve, and the tibial (internal popliteal) nerve. When these are found severed, an attempt at repair should be made, provided the injury is fresh. In an infected wound nerve suture is futile and dangerous. Later tendon transplantation can be done to compensate for nerve injuries, or the severed ends can be dissected from scar tissue and the ends cleaned and sutured.

Later Treatment.—The condition in which prophylactic use of a sulfonamide was valuable was a late wound, twenty-four or forty-eight hours or perhaps a week after infection, requiring operation and suggesting the possibility of a flareup. If a full dose was given by mouth beforehand, intervention was safer. A few doses would on most occasions deal with an acute streptococcic infection, but not with a chronic one. When the infection was in the blood the drug was not of the same value as when it was in the body tissues. The same held true for gas gangrene.

A sulfonamide derivative is valuable in a case of secondary operation in which there was a suspicion of hemolytic streptococcus infection. Prophylactic treatment should be administered in four hourly doses. In long-standing or superficial cases, such as old burns and road accidents which led to infection, the application of sulfanilamide powder gave astonishingly good results. Where the drug cannot be taken by mouth, the soluble sodium salt (sodium sulfapyridine) may be used.

When injured men come under observation at a late period when the organisms of gas gangrene have already reached the living tissues bordering on the wound cavity or when the wound is passing through a stage of physiological reaction to injury, the time for prophylactic excision has passed and the surgeon must aim at providing adequate drainage by incision. In late cases, however, in which there is any suspicion of gangrenous infection of muscle, the wound must be opened up and the muscles affected must be extensively excised.

The best available treatment for the established case of gas gangrene, in addition to surgery, is a combination of antitoxin and chemo-

therapy. The serum and drug seem to have a synergic action, the former neutralizing the bacterial toxin, while the latter exercises a bacteriostatic effect on the organism. The antitoxin should be administered, preferably intravenously, at the earliest possible moment.

Many serious *contractures* of the foot and ankle can be prevented if the foot is kept in proper position during the period of treatment. A simple posterior molded splint made of almost any rigid material will suffice. If the foot is kept at a right angle to the leg with the toes pointing to the ceiling and in direct line with the patella, it will be possible to start active motion earlier and it will be accompanied by less pain. These principles hold true in crushing or severe soft tissue injuries to the leg, foot and ankle, regardless of bony involvement.

With the mechanization of modern warfare, the type of injury to the foot and ankle has become much more severe. The injuries today are of a severe crushing type, being caused by high explosives, or being run over by heavy mechanized army equipment. With such ripping and tearing injuries, the tissues have a wider area which will be contused and abraded, and hence must be débrided widely.

Tetanus antitoxin and gas bacillus serum should be given routinely to every patient with a severe injury of the foot and ankle, regardless of what surgery or chemotherapy is instituted.

Amputation for soft tissue injuries of the lower leg becomes necessary only when there is complete devitalization of the part with impending spread of gangrene. Amputations for gangrene and gas gangrene should be well above the area of involvement.

Factors in Wound Healing (Mason).—1. *Blood Supply.*—Tight sutures and tight bandages may render portions of tissue avascular and result in local necrosis. Following closure of a wound, vascular stasis, edema and hemorrhage may also cause local circulatory disturbances. The venous return of the leg is often markedly improved by slight elevation. Support by a firm, semi-elastic, but not tight bandage prevents serum from accumulating.

2. *Irritants* of various sorts lower tissue vitality, and may even bring healing to a standstill. These irritants include antiseptic drugs and chemicals. Recent experiments have shown that when sulfanilamide or its allied compounds are used locally in excess, delay in healing may result.

3. *Mechanical or chemically inert irritants*, such as foreign bodies, may carry infecting organisms into a wound, or their presence may interfere with healing. The surgeon should put into the wound the least amount of foreign material compatible with a satisfactory repair. The present trend is toward the use of fine silk, steel or cotton in clean wounds. Only the finest catgut which will hold the tissues properly apposed should be used.

Drains interfere with healing and have no place in properly treated fresh injuries. If infection is feared, the wound may be cleansed and left open to be closed later.

4. *Hemorrhage and blood clots* interfere with healing by preventing apposition of divided tissue, by interfering with local circulation and by furnishing a culture medium for bacterial growth.

5. *Accurate anatomical restoration* of divided structures lays the groundwork for rapid healing.

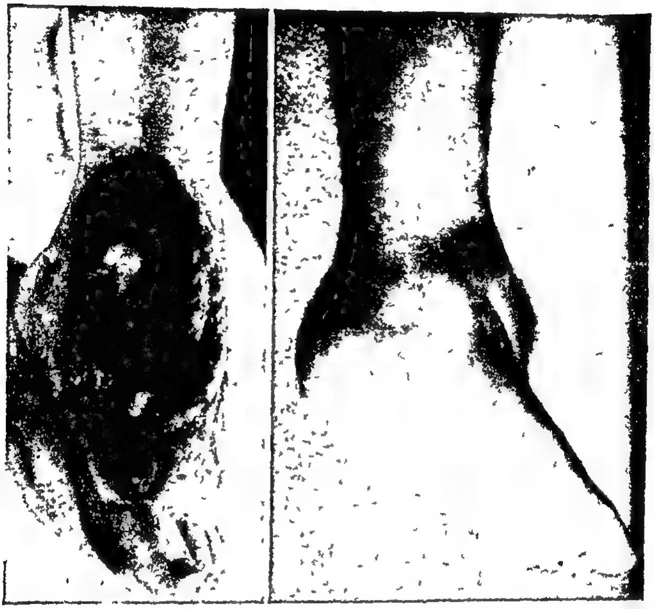


FIG 245 —*A*, left, Appearance of lesion on February 11, 1936, five years after the accident. During these five years the wound had failed to heal sufficiently to justify attempting a skin graft. *B*, Showing successful skin graft on April 7, 1936 (Tompkins, Crock, Haynes and Winters, courtesy of Surg., Gynec. and Obst.)

6. *Rest, support and protection* to the healing tissues until such time as they may resume normal function is a basic principle common to most methods of wound therapy. Immobilization is needed until the stage of fibroplasia is well under way, and this is never less than twelve to fourteen days. In the case of the healing tendon, restricted use following an initial complete immobilization of twelve to fourteen days promotes a more rapid increase in tensile strength than does continuation of the rigid immobilization. However, it should be emphasized that this use at first must be limited by a splint so that the tendon cannot be extended beyond the point at which it was originally fixed; otherwise stretching of the union and increased reaction occur.

7. *Non-viable and necrotic tissue*, by requiring absorption and extrusion, unduly prolong healing and favor infection. Adequate débridement cannot be overemphasized.

8 *Wound contamination* depends largely on the tissue soil under which the bacteria may grow Healthy tissues may often cope with virulent bacteria while weak and devitalized tissues may fall prey to organisms of relatively low virulence The length of time the organisms have been in the tissues is of great importance If they have been present for a time less than their period of incubation, mechanical cleansing is possible

9 *General factors* such as overhydration or dehydration, nutritional factors and vitamins also play an important rôle in wound healing

It is considered that the chief metabolic prerequisite in the healing of wounds is a blood protein content of 6 5 grams per cent

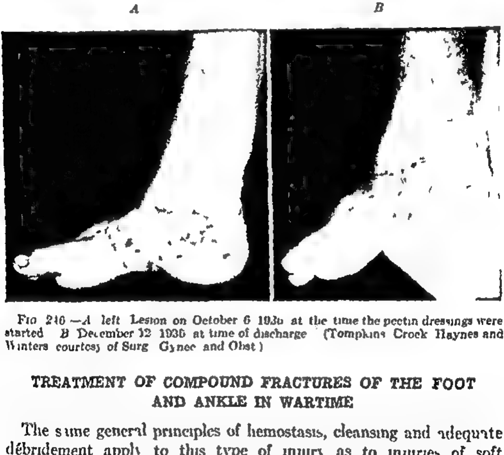


Fig 240 —*A* left Lesion on October 6 1936 at the time the pectin dressings were started *B* December 12 1936 at time of discharge (Tompkins Crock Haynes and Winters courtesy of Surg Gynec and Obst)

TREATMENT OF COMPOUND FRACTURES OF THE FOOT AND ANKLE IN WARTIME

The same general principles of hemostasis, cleansing and adequate débridement apply to this type of injury as to injuries of soft tissues If there is a punctured wound in the area overlying the fracture it should be thoroughly cleansed with soap and water, the edges of the wound débrided and the wound opened as wide as necessary by incision Direct observation of the deep tissues and of the fracture should be scrupulously made Depending upon the type of fracture present, it may become necessary to (1) reshape the ends of the bony fragments, (2) stabilize the fragments in position by traction, (3) immobilize the fragments by internal fixation

Sir Thomas Dunhill reported the progress of 65 patients whose knees and ankles were broken, "Pus was soaking through the plaster, and the stench was beyond belief. In World War I, perhaps three-fourths would require amputation, and streptococcic septicemia would have occurred. They were treated by fixation and a sulfonamide derivative for a number of days until it was felt that appropriate doses had been given. Two died from secondary hemorrhage and one from gas gangrene, but all the rest did well." He believed that three-fourths of the results were due to fixation and the rest to the sulfonamide derivative. These two measures seemed to be able to stop the spread of infection. If a cast is to be applied for fixation, windows should not be cut for dressing the wound. It is much more advisable to change the cast at given intervals or use a posterior mold, because of the danger of "window-edema," which may result from the former practice. While it is possible in some compound fractures which occur in civilian practice to fix the fracture with internal plates and close the wound, it is not advisable in most wartime injuries. On the other hand, if a compound fracture is seen very early, it may be possible to clean the wound out thoroughly, apply sulfanilamide powder and close the wound by widely separated sutures. The occurrence of osteomyelitis in such fractures has been very low.

Treatment by Closed Method.—The closed method consists of immediate débridement after reduction of the fracture and immobilization in a plaster cast. There were only 6 deaths in one series and only 1 case of gas gangrene. Some 20,000 cases were treated by this method. The Orr method was employed over thirty months of continual treatment of war casualties, including the immediate surgical treatment of casualties in over 300 air raids. The essential procedure in the "closed" treatment of compound fractures is one of débridement. The factor of vitality of tissues is the decisive element in infections. The greatest danger of infection lies in devitalized muscle. The other factor, is the length of time elapsing before treatment is instituted. Shock has been observed only in those cases in which there is delay in treatment which permits absorption from devitalized muscle. The important principles in this treatment consist of: (1) extensive and accurate débridement with removal of all foreign matter; (2) reduction of the fracture; (3) after reduction, im-

rigidly straight were current observations as soon as the plaster was removed. This method of treatment should be used only under unusual war conditions, namely, a great mass of wounded, or when there is difficulty in evacuation, reduced trained personnel, lack of dressings, etc.

The principle of continuity of treatment and of surgical responsibility must be observed in all cases. This can be achieved best if the patient is kept at one installation. It is also recommended that there be standardization of stretchers so that a wounded person need not be moved from his original stretcher until the operating room is reached.

Dunhill advises: Universal agreement on débridement, reduction under mechanical traction and anesthesia, controlled by roentgenograms, with packing of the wound, free drainage into a completely closed and immobilizing plaster cast, which was allowed to remain *in situ* without change, until the healing of the wound had advanced sufficiently to become protected by granulation against secondary infection. Thus, the Orr treatment applied to dirty fracture wounds often prevented osteomyelitis.

Mild sepsis is known to be a stimulant to bone granulations and if apposition of the fragments is secured, even while a portion is being extruded as a sequestrum, union will take place.

Osteomyelitis Complicating War Wounds.—The most common cause of osteomyelitis complicating war wounds is a direct gunshot wound causing a fracture. Through and through wounds are usually sterile. The immediate consequence of infection is acute osteomyelitis. As a projectile strikes the compact bone, it generally fractures it completely. Comminution may completely shatter the bone at the point of the injury or produce fissures or cracks that radiate up and down the shaft of the bone. The treatment is the control of the infection, the removal of sequestra and necrotic bone, and obliteration of the cavity.

Hemorrhage is controlled by the frequent application of large pieces of gauze wrung out of very hot saline solution. After exposure, the periosteum should be incised. Before the bone is attacked, it should be packed off by means of gauze pads, partly to prevent fragments of bone from getting lost among the soft parts and being left behind.

Complete excision of the sinus leading to the bone cavity and of the surrounding scar tissue is necessary. Sulfathiazol powder is sprayed into the wound and the layers can be closed as in any clean surgical wound. A high percentage of these wounds will heal by primary union.

It is now agreed that the incidence of osteomyelitis complicating war wounds can be radically reduced if proper treatment is instituted shortly after the initial injury. This consists in adequate débridement, and the additions of chemotherapy and the "closed" method of treatment.

TREATMENT OF SUPPURATIVE ARTHRITIS OF THE ANKLE AND JOINTS OF THE FOOT DUE TO WAR WOUNDS

When compound fractures occur about the foot and ankle, very often there is a concomitant dislocation of ankle joint or the joints of the foot, with exposure of the joint to gross infection. When such a condition exists, one must keep in mind the possibility of suppurative arthritis developing in the joint.

Other causes for suppurative arthritis due to war injury are bullet and shrapnel wounds which carry infection into joint spaces, crushing injuries, explosions, and even blunt injuries which do not apparently cause disruption of the skin. Osteomyelitis occasionally gives rise to suppurative arthritis in the neighboring joint. The signs, symptoms, physical findings and roentgen-ray findings are well known. Diagnostic aspiration with needle and syringe is important.

When there is an open wound and the injury is fresh, suppurative arthritis can often be prevented by painstakingly thorough cleansing, irrigation with salt solution, and débridement before reducing the dislocation or repairing the joint capsule. In these recent injuries no drainage directly from the joint should be allowed. The wound, however, may be closed or allowed to drain into a vaseline pack, depending upon judgment of the surgeon in regard to the contingency of infection. The extremity is placed in a cast or splint.

If the joint is already grossly infected, free through and through drainage, by incision if necessary, should be instituted at the earliest possible moment. Irrigations should be carried out repeatedly. If the overlying skin is unbroken, and the diagnosis of suppurative arthritis is obvious, free incision, evacuation of pus, and irrigations should be begun at once. In making the incisions one should avoid all large nerves and blood-vessels. One of the favorite solutions for irrigation is 1 to 15,000 bichloride of mercury in salt solution as recommended by Cotton for irrigating suppurative knee joints. A very important consideration is the mechanical irrigation rather than chemical sterilization. The irrigation should proceed with quart upon quart of solution and not depend upon the number of minutes used in irrigating. The slogan is: "Gallons not minutes."

The following program is advised:

1. Mild cases are treated with aspiration. Irrigation and instillation of penicillin solution every twenty-four to forty-eight hours is done together with intramuscular penicillin therapy until the clinical course shows the sepsis to be controlled. The usual amount is 100,000 units per day. Usually 5 to 10 cc. of penicillin solution is instilled into the joint each time.

2. In severe cases, wide arthrotomy is done to remove dead or damaged cartilage, remove foreign bodies in the area (an important

cause of sepsis), the joint is irrigated, synovia closed and penicillin solution instilled as above In addition parenteral penicillin therapy is used as above When one is not sure about the cause of joint sepsis, an arthrotomy is performed for observation purposes As a rule, the really septic joints show cartilage damage at the time of operation

With penicillin therapy the creamy pus soon becomes mucoid in character and the rough surfaces are replaced by a smooth articular layer

FIG 247 —End result of a fracture through the subastragalar joint resulting in a traumatic arthritis with pain deformity and disability (Courtesy of C J Challenger)

Drains are to be avoided if possible because of the danger of traumatizing the synovia and because of the possibility of secondary infection becoming superimposed The limb should be protected by means of a cast or splint The various preparations, given by mouth, or implanted directly into the wound are of definite value

Passive motion should be begun as soon as possible through the "short arc" This is soon followed by active motion, guided by pain

The Willems treatment calls for immediate passive and active movement. This did much to prevent adhesions and ankylosis.

TREATMENT OF BURNS

Burns differed from those of civilian life in that the military burns might not be treated for many hours or even days. On a warship only can first-aid treatment be given in the majority of cases. Most of the burns are due to gun flash, bomb flash, incendiary bombs or gasoline. First-aid treatment consists of morphine, warmth and fluids to counteract shock. If this was marked, plasma transfusion was given. Secondary shock occurs some hours after the burn and accounts for 80 per cent of the deaths.

The most important factor in shock is the loss of plasma from the burned surface. The blood might be so concentrated that the hemoglobin rises to 140 per cent. The best treatment is to replace the plasma protein. Given intravenously, plasma raises the osmotic pressure sufficiently to restore the normal distribution of fluid between the vascular and interstitial components. Whole blood transfusion and intravenous physiological solution of sodium chloride or sterile water are usually contraindicated. The amount of plasma necessary must be estimated by frequent blood examinations.

Acute toxemia from burns is due to streptococcic infection. It does not appear for several days and can be prevented by primary cleansing before coagulation. For extensive burns with toxemia, saline baths prove valuable. In first- or second-degree burns, sepsis can be prevented if coagulation treatment is given at once and adequate cleansing and coagulation are carried out on arrival at a hospital.

With regard to local treatment, gentian violet jelly with merthiolate (1 to 5,000) can be applied to the burned areas without any cleansing. The application should be liberal, for it is painless and even soothing. It seals off the burned area and forms a crust which remains until arrival at a hospital. Local treatment should not be given in the presence of shock.

In the hospital the treatment of shock is instituted, and plasma banks and dried plasma play an important part. Oxygen administration is helpful. After shock has been treated the patient is taken to a warm room and anesthetized with gas and oxygen. The burned area is thoroughly cleansed with saline solution, dried with an electric hair drier and two applications of an aqueous solution of triple dye (2 per cent gentian violet, 1 per cent brilliant green and 0.1 per cent acriflavine) sprayed on the surface. This produces a thin, supple, adherent tan, which loosens about the eighth day and gradually falls off, leaving a healed area. If the burn is extensive and of third degree, the area should be excised and skin grafted.

Sepsis occurs predominantly in deeply burned areas, and the object of coagulation, which does not penetrate more than a millimeter of tissue, is to make the conditions for bacterial growth as unsuitable as possible. This is done more effectively by coagulation than by any other form of local treatment. In first- or second-degree burns, coagulation gives excellent results. Chemotherapy can be used if indicated. But where the loss of skin is complete coagulation usually fails, particularly in regard to ultimate function. In these cases it is impossible to tan or coagulate the entire area. A heavily infected granulating surface is exposed in which healing might be slow and painful, and during this phase the patient might become wasted and anemic from chronic sepsis. Under the unyielding tannic acid, edema can develop to a degree which produces further deformity. In third-degree cases treatment should be directed toward obtaining the best granulating surface for skin grafting. A thermostatically controlled saline bath, followed by saline packs and later by Thiersch grafts is advocated.

Envelope Method of Treating Burns.—Bunyan described a closed method for constant bathing of a limb whose surface has been largely denuded by a burn.

The treatment consists of irrigating the burned area with a 5 per cent solution of electrolytic hypochlorite at 100° F., and then applying a coated-silk envelope over the burned limb.

GAS GANGRENE

Gas gangrene is a spreading, moist gangrene produced by gas-forming anaerobic bacteria in extensively traumatized tissues. It is usually characterized by a gaseous infiltration and edema of the part and a change in the color and contractility of the muscles affected. It usually follows crushing injuries of the tissues, especially of the skin and muscles, with contamination by clothing or soil which has been contaminated by animal excreta. It may follow a compound fracture.

Prior to World War I, gas gangrene was considered a clinical curiosity but during that war the incidence of the condition was very high because many of the battles were fought on highly fertilized soil, in which the spores of gas bacilli were very numerous. In open crushing wounds, lacerations, injuries caused by explosives and compound fractures which have been contaminated by earth or cloth, especially wool, the danger of anaerobic infection is to be feared if there is injury to the local blood supply. A wound contaminated by garden soil is a potential site for gas gangrene.

Gas-bacillus infection may develop in any wound of the lower extremity resulting from impairment of the circulation regardless of the age of the patient or whether the gangrene is moist or dry or the skin is

The Willems treatment calls for immediate passive and active movement. This did much to prevent adhesions and ankylosis.

TREATMENT OF BURNS

Burns differed from those of civilian life in that the military burns might not be treated for many hours or even days. On a warship only can first-aid treatment be given in the majority of cases. Most of the burns are due to gun flash, bomb flash, incendiary bombs or *gasoline.* First-aid treatment consists of morphine, warmth and fluids to counteract shock. If this was marked, plasma transfusion was given. Secondary shock occurs some hours after the burn and accounts for 80 per cent of the deaths.

The most important factor in shock is the loss of plasma from the *burned surface. The blood might be so concentrated that the hemo*globin rises to 140 per cent. The best treatment is to replace the plasma protein. Given intravenously, plasma raises the osmotic pressure sufficiently to restore the normal distribution of fluid between the vascular and interstitial components. Whole blood transfusion and intravenous physiological solution of sodium chloride or sterile water are usually contraindicated. The amount of plasma necessary must be estimated by frequent blood examinations.

Acute toxemia from burns is due to streptococcic infection. It does not appear for several days and can be prevented by primary cleansing before coagulation. For extensive burns with toxemia, saline baths prove valuable. *In first- or second-degree burns, sepsis can be pre*vented if coagulation treatment is given at once and adequate cleansing and coagulation are carried out on arrival at a hospital.

With regard to local treatment, gentian violet jelly with merthiolate (1 to 5,000) can be applied to the burned areas without any cleansing. The application should be liberal, for it is painless and even soothing. It seals off the burned area and forms a crust which remains until arrival at a hospital. Local treatment should not be given in the presence of shock.

In the hospital the treatment of shock is instituted, and plasma banks and dried plasma play an important part. Oxygen administration is *helpful. After shock has been treated the patient is taken to a warm* room and anesthetized with gas and oxygen. The burned area is thoroughly cleansed with saline solution, dried with an electric hair drier and two applications of an aqueous solution of triple dye (2 per cent gentian violet, 1 per cent brilliant green and 0.1 per cent acriflavine) sprayed on the surface. This produces a thin, supple, adherent tan, which loosens about the eighth day and gradually falls off, leaving a healed area. If the burn is extensive and of third degree, the area should be excised and skin grafted.

Sepsis occurs predominantly in deeply burned areas, and the object of coagulation, which does not penetrate more than a millimeter of tissue, is to make the conditions for bacterial growth as unsuitable as possible. This is done more effectively by coagulation than by any other form of local treatment. In first- or second-degree burns coagulation gives excellent results. Chemotherapy can be used if indicated. But where the loss of skin is complete coagulation usually fails, particularly in regard to ultimate function. In these cases it is impossible to tan or coagulate the entire area. A heavily infected granulating surface is exposed in which healing might be slow and painful, and during this phase the patient might become wasted and anemic from chronic sepsis. Under the unyielding tannic acid, edema can *develop to a degree which produces further deformity. In third-degree* cases treatment should be directed toward obtaining the best granulating surface for skin grafting. A thermostatically controlled saline bath, followed by saline packs and later by Thiersch grafts is advocated.

Envelope Method of Treating Burns.—Bunyan described a closed method for constant bathing of a limb whose surface has been largely denuded by a burn.

The treatment consists of irrigating the burned area with 1.5 per cent solution of electrolytic hypochlorite at 100° F., and then applying a coated-silk envelope over the burned limb.

GAS GANGRENE

Gas gangrene is a spreading, moist gangrene produced by gas-forming anaërobic bacteria in extensively traumatized tissues. It is usually characterized by a gaseous infiltration and edema of the part and a change in the color and contractility of the muscles affected. It usually follows crushing injuries of the tissues, especially of the skin and muscles, with contamination by clothing or soil which has been contaminated by animal excreta. It may follow a compound fracture.

Prior to World War I, gas gangrene was considered a clinical curiosity but during that war the incidence of the condition was very high because many of the battles were fought on highly fertilized soil, in which the spores of gas bacilli were very numerous. In open crushing wounds, lacerations, injuries caused by explosives and compound fractures which have been contaminated by earth or cloth, especially wool, the danger of anaërobic infection is to be feared if there is injury to the local blood supply. A wound contaminated by garden soil is a potential site for gas gangrene.

Gas-bacillus infection may develop in any wound of the lower extremity resulting from impairment of the circulation, regardless of the age of the patient or whether the gangrene is moist or dry or the skin is

intact or broken. It is seen most commonly in military and industrial practice; it may follow athletic and automobile injuries. The chief organisms of the gas gangrene group of anaërobes includes the Bacillus welchii and the Vibrion septique. Vincent found Vibrion septique in about 10 per cent of cases. Streptococci and staphylococci may be secondary invaders.

According to Dieterle, gas gangrene is always a muscle disease and advances longitudinally. In the early stages, it is limited to one muscle, or a group of muscles. If the pressure of fluid and gas is not relieved, death of the tissue results from strangulation of the circulation. Muscles confined in rigid compartments, such as the tibialis anticus, become gangrenous rapidly. The infection advances in muscle rather than in the intermuscular planes.

The symptoms and signs of gas-bacillus infection are fever, an increased pulse rate, pain, swelling, discoloration, tenderness, subcutaneous swelling, muscle swelling and crepitus. The physical findings include swelling, tenderness, crepitus, a peculiar odor and an inflammable gas. The roentgen-ray reveals shadows like bubbles in or between the muscles and in the skin.

The first symptom is an increase in the pulse rate which may or may not be accompanied by fever. Crepitation, a very important sign, is due to the presence of gas in the tissues. A peculiar odor described as a "mousy smell" emanates from the open wound. The leukocyte count is increased. Restlessness and uneasiness are followed by prostration and toxemia.

Culture material should be taken directly from the wound by means of sterile applicators and planted in 10 cc. of a fresh meat extract bouillon with a faintly alkaline reaction and a 1 per cent content of dextrose. The culture medium should then be covered with liquid petrolatum to a depth of 1 cc. and incubated at 37.5° C. (99.5° F.). The appearance of bubbles after six hours indicates the presence of a specific organism, and penetration of the oil layer by the bubbles is evidence that the organism is the Bacillus welchii. The diagnosis should be confirmed by the examination of smears for large Gram-positive bacilli, and by animal inoculation.

Tenopyr called attention to early suggestive symptoms: (1) pain disproportionate to the amount of injury; and (2) the mental acuteness of the patient. Locally, there is disproportionate swelling with pallor of the surrounding skin. The edges of the wound are of a dirty cream color, and the bandages are stained with a red serum. There is no pus. Bubbles and gas can be milked out of the wound, and crepitation felt under the skin. After twenty-four hours, the area is covered with a dirty, greenish-gray membrane, a characteristic odor is noted, and there is usually a thin discharge.

Roentgen-ray Findings —G G Davis was the first to recognize gas bubbles in the roentgenogram in early cases of gas gangrene Olin found that the roentgenogram will reveal the presence of free gas in the tissues in the first twenty-four hours A small black spot, blotchy in outline, is the first evidence, and if carefully visualized can be followed along the course of a muscle As the infection travels along the muscle fibers and rarely transversely, longitudinal shadows are the rule To prevent confusion of shadows, the limb should be free from splints and dressings, and dry The prognosis depends upon the severity of the infection and the time that elapses between the injury and the institution of prophylactic measures

Treatment includes prophylaxis, surgery, oxygen injection, serotherapy, and roentgenotherapy Surgery includes drainage, débridement, including affected muscle masses, sterilization by irrigations or maggots, prophylactic incisions in advance of the infection, and amputation As prophylactic treatment, the intramuscular injection of from 30 to 60 cc of polyvalent antigas-gangrenous serum combined with 1,500 units of antitetanus serum is recommended

Débridement includes the removal of all foreign material and devitalized tissue until the area of healthy muscle is reached, as shown by bleeding, contractility and color

After débridement and incision, the wound should be left open for drainage and exposure to the air Various substances are used for irrigation, including hydrogen peroxide, potassium permanganate, quinine sulphate, formalin, and chloramine Larson and Pulford recommend flushing of the wound with chloramine solution by the Carrel technic every three hours and its immersion in this solution for one-hour periods three or four times a day Some workers favor continuous irrigation with Dakin's solution or daily irrigations with potassium permanganate All wounds should be packed lightly with wet gauze

Speed recommended the removal of whole groups of muscles, because the infection spreads through the muscle itself, rather than by way of the lymphatics or blood stream After removing the muscle mass, he leaves the wound wide open and treats it by the Carrel-Dakin method Baer found maggots most effective in cleaning up the infection Caldwell has recently reported favorable results following the use of zinc peroxide paste Kelly of Omaha has had success in the treatment of gas gangrene with the use of roentgen-ray therapy

A report from the War Wounds Committee of the Medical Research Council and the Committee of London Sector Pathologists indicates that the best available treatment, in addition to surgery, for the established disease is a combination of antitoxin and chemotherapy with *sulfanilamide or sulfapyridine* The antitoxin should be ad-

intact or broken. It is seen most commonly in military and industrial practice; it may follow athletic and automobile injuries. The chief organisms of the gas gangrene group of anaërobes includes the Bacillus welchii and the Vibrion septique. Vincent found Vibrion septique in about 10 per cent of cases. Streptococci and staphylococci may be secondary invaders.

According to Dieterle, gas gangrene is always a muscle disease and advances longitudinally. In the early stages, it is limited to one muscle, or a group of muscles. If the pressure of fluid and gas is not relieved, death of the tissue results from strangulation of the circulation. Muscles confined in rigid compartments, such as the tibialis anticus, become gangrenous rapidly. The infection advances in muscle rather than in the intermuscular planes.

The symptoms and signs of gas-bacillus infection are fever, an increased pulse rate, pain, swelling, discoloration, tenderness, subcutaneous swelling, muscle swelling and crepitus. The physical findings include swelling, tenderness, crepitus, a peculiar odor and an inflammable gas. The roentgen-ray reveals shadows like bubbles in or between the muscles and in the skin.

The first symptom is an increase in the pulse rate which may or may not be accompanied by fever. Crepitation, a very important sign, is due to the presence of gas in the tissues. A peculiar odor described as a "mousy smell" emanates from the open wound. The leukocyte count is increased. Restlessness and uneasiness are followed by prostration and toxemia.

Culture material should be taken directly from the wound by means of sterile applicators and planted in 10 cc. of a fresh meat extract bouillon with a faintly alkaline reaction and a 1 per cent content of dextrose. The culture medium should then be covered with liquid petrolatum to a depth of 1 cc. and incubated at 37.5° C. (99.5° F.). The appearance of bubbles after six hours indicates the presence of a specific organism, and penetration of the oil layer by the bubbles is evidence that the organism is the Bacillus welchii. The diagnosis should be confirmed by the examination of smears for large Gram-positive bacilli, and by animal inoculation.

Tenopyr called attention to early suggestive symptoms: (1) pain disproportionate to the amount of injury; and (2) the mental acuteness of the patient. Locally, there is disproportionate swelling with pallor of the surrounding skin. The edges of the wound are of a dirty cream color, and the bandages are stained with a red serum. There is no pus. Bubbles and gas can be milked out of the wound, and crepitation felt under the skin. After twenty-four hours, the area is covered with a dirty, greenish-gray membrane, a characteristic odor is noted, and there is usually a thin discharge.

Roentgen-ray Findings.—G. G. Davis was the first to recognize gas bubbles in the roentgenogram in early cases of gas gangrene. Olin found that the roentgenogram will reveal the presence of free gas in the tissues in the first twenty-four hours. A small black spot, blotchy in outline, is the first evidence, and if carefully visualized can be followed along the course of a muscle. As the infection travels along the muscle fibers and rarely transversely, longitudinal shadows are the rule. To prevent confusion of shadows, the limb should be free from splints and dressings, and dry. The prognosis depends upon the severity of the infection and the time that elapses between the injury and the institution of prophylactic measures.

Treatment includes prophylaxis, surgery, oxygen injection, serotherapy, and roentgenotherapy. Surgery includes drainage, débridement, including affected muscle masses, sterilization by irrigations or maggots, prophylactic incisions in advance of the infection, and amputation. As prophylactic treatment, the intramuscular injection of from 30 to 60 cc. of polyvalent antigas-gangrenous serum combined with 1,500 units of antitetanus serum is recommended.

Débridement includes the removal of all foreign material and devitalized tissue until the area of healthy muscle is reached, as shown by bleeding, contractility and color.

After débridement and incision, the wound should be left open for drainage and exposure to the air. Various substances are used for irrigation, including hydrogen peroxide, potassium permanganate, quinine sulphate, formalin, and chloramine. Larson and Pulford recommend flushing of the wound with chloramine solution by the Carrel technic every three hours and its immersion in this solution for one-hour periods three or four times a day. Some workers favor continuous irrigation with Dakin's solution or daily irrigations with potassium permanganate. All wounds should be packed lightly with wet gauze.

Speed recommended the removal of whole groups of muscles, because the infection spreads through the muscle itself, rather than by way of the lymphatics or blood stream. After removing the muscle mass, he leaves the wound wide open and treats it by the Carrel-Dakin method. Baer found maggots most effective in cleaning up the infection. Caldwell has recently reported favorable results following the use of zinc peroxide paste. Kelly of Omaha has had success in the treatment of gas gangrene with the use of roentgen-ray therapy.

A report from the War Wounds Committee of the Medical Research Council and the Committee of London Sector Pathologists indicates that the best available treatment, in addition to surgery, for the established disease is a combination of antitoxin and chemotherapy with *sulfanilamide or sulfapyridine*. The antitoxin should be ad-

ministered, preferably intravenously, at the earliest possible moment. The dose of polyvalent antitoxin recommended is 7,500 international units of Clostridium welchii, 3,750 international units of Clostridium septique and 2,500 of Clostridium œdematiens, repeated as necessary. The first dose of sulfapyridine or sulfanilamide should be 2 grams dissolved in hot citric acid or lemon solution. Subsequent doses, starting two hours later and repeated every four hours for two days, should be 1 gram uncrushed. After the first two days the dose should be gradually reduced as the condition improves, but the interval between the doses should not be more than six hours for several days. Small doses of 3 grams daily should be continued for three or four days after the temperature has become normal. The duration of treatment and the total dosage will vary somewhat, but the latter should seldom exceed 35 grams.

Supportive measures should be instituted to combat the infection. In some cases, general measures such as blood transfusion are necessary because of hemorrhage or a blood-destroying toxin. In severe cases, failure to amputate may result in loss of life. Pennoyer reported a case of traumatic amputation of the thigh complicated by both tetanus and gas gangrene in which recovery resulted.

AMPUTATION IN INFECTED WOUNDS

Amputation should not be attempted in recent wounds except possibly when a mangled limb must be removed within an hour or two of injury. The aim of the surgeon who removes a limb for infection or secondary hemorrhage is to insure, if possible, that a good stump can be made later. The two immediate necessities are to save life and to satisfy as far as possible the principle that protective barriers should not be transgressed. But there is no excuse under any conceivable circumstances for a true guillotine amputation. Ogilvie expresses the opinion that these amputations, tragic blunders of the early phases of World War I, cause shock at the time and unnecessary loss of fluids afterwards, while later the stump becomes a cone of bleeding granulations with necrotic bone at its apex. The skin cannot be made to meet even with all the devices of traction and reamputation, and an unnecessary loss of length is inevitable. The guillotine operation was introduced as a time-saver, but the only time it saves is that necessary to turn back a skin cuff, a few strokes of the knife. Time is spent chiefly in finding and ligating vessels and there are as many in a guillotine operation as in a proper plastic procedure. McKeever advised a revision of our concept of the "guillotine" operation.

The level at which a limb is removed will depend upon the indication for amputation; if the operation is for gas gangrene, section should be

as nearly as possible at the upper level of the gangrenous muscles, and disarticulations at the knee will often be called for. Disarticulations at the hip are too severe. If the indication is secondary hemorrhage or gross infection, removal of the limb will often be at the level of the wound itself, the flaps being cut away from it on each side. Where there is fracture, the soft tissues are cut if possible to cover the end of the shaft, and avoid fresh bone section at the time. Where there is no choice, the longest possible stump will be made.

The technic should be as simple as possible with rapid sweeps of a large knife. A 2-inch cuff of skin or flaps is turned back, the muscles are cut obliquely upwards toward the center of a limb and the bone is divided with as little preliminary separation of its surroundings as possible. Hemostasis must be complete. The flaps must be left wide open, but that does not require that they be exposed to the air. Strips of vaseline gauze are laid across them to cover the whole surface of the flaps and project at the sides, and the skin in front and behind is brought over the gauze by three or four sutures. The stump is then bandaged to a splint which projects about 6 inches beyond it to give it rest, and protect it from injury. A stump cut and dressed in this way is better drained than a guillotine, and will usually heal with little subsequent attention.

Foot and Ankle.—The classical amputations of Lisfranc, Chopart, and Pirogoff are still described and often recommended in many standard surgical texts, but with the possible exception of the Lisfranc amputation through the tarso-metatarsal joints, these amputations are undesirable from the prosthetic and functional viewpoints.

In this country, where the art of limb making is so highly developed and adequate prostheses are easily obtained, Thomas and Hadden prefer amputations at a higher level.

In the Chopart amputation, which leaves only the astragalus and os calcis, equinus deformity of the stump almost inevitably develops. It is also difficult to fit a satisfactory prosthesis for such a stump. In Pirogoff's amputation the tibia and fibula are severed just above the ankle joint, while the posterior portion of the os calcis is sawed vertically, left attached to the long posterior flap and opposed to the cut surface of the tibia. This amputation requires careful surgical technic and non-union of the opposed bones with deformity often results. The operation is doomed to failure in the presence of infection or peripheral vascular disease. With a successful Pirogoff stump the prosthesis is bulky and unsightly, and allows no room for the ankle-joint mechanism. It has the advantage that a prosthesis is not essential for weight-bearing or locomotion.

The Syme's amputation, which is performed through the malleoli just above the ankle-joint is highly recommended.

Canadian surgeons believe it gives the best stump of any of the lower extremity. The operation is also recommended by many experienced surgeons in the United States. All agree, however, that because of its location and the meticulous technic and optimum conditions required for its successful performance it has a limited usefulness. The Syme's prosthesis is bulky and unsightly as well as heavy and for this reason the operation is not so highly recommended for women.

Amputations Between the Ankle and the Knee.—Amputations through the middle of the leg are inadvisable.

The length of the ideal stump in below-knee amputations, is 5 to 6 inches measured from the superior border of the tibia. Four inches is sufficient for good leverage but it is better to have an inch or two to spare in case there is some trouble in healing and the skin edges pull apart or slough, necessitating reoperation and removal of more bone.

The shortest stump that can be fitted successfully with a below-knee prosthesis depends more upon the bulk and redundancy of the soft tissues than upon actual bone length. Theoretically any amputation below the level of the attachment of the quadriceps tendon into the tibial tubercle would permit voluntary control in extending the shin of the prosthesis, no matter how short the stump; but when the knee is flexed, sufficient length is necessary to retain the stump within the socket. About 2 inches of tibial length is the minimum, although shorter stumps can occasionally be fitted. Even where the bone length is prohibitively short, a "kneeling type" of end-bearing prosthesis, in which the weight is carried with the knee flexed, can be worn satisfactorily. It is the opinion of some that this type of stump is just as satisfactory as an end-bearing stump through or just above the knee.

Amputations Through or Just Above the Knee Joint.—These amputations are designed for complete end-bearing. Those in most common use are the following:

Gritti-Stokes Amputation.—This is a supracondylar amputation in which the patella, after removal of its articular cartilage is secured with its attached quadriceps ligament to the cut surface of the lower end of the femur. Its success depends upon bony union between the patella and femur and a skin flap with good blood supply. When successful, the stump will bear full body weight on its end for long hours, with complete comfort. It is a popular operation with the surgeons of the Department of Pensions and National Health of Canada, and in their experience, gives a very durable stump that stands up well over a period of years with full end-bearing. In their opinion "it is the best of all above-knee amputations" (Harris). It is not popular in England, however.

Supracondylar Tendoplastic Amputation.—This method described by Kirk, is carried out through the cancellous bone of the supracondylar region of the femur below the shaft. The quadriceps tendon, which is

included in a long anterior skin flap, is cut close to its patellar attachments, brought over the end of the sectioned femur, and sutured to the fascia posteriorly. This method is widely used in the Amputation Centers of the United States Army. According to Kirk, it gives "an ideal stump, full end-bearing, symmetrical in contour, free from spurs, and of maximum functional length."

Callander Amputation.—This is a supracondylar amputation with minimal tissue dissection, devised primarily for use in the aged, in arteriosclerotics, and in cases of diabetic gangrene. In this operation no muscle tissue is incised and the patella is removed intact and incorporated in the long anterior skin flap, which is brought over the end of the femur and sutured loosely to the shorter posterior skin flap.

Rogers Amputation Through Knee-joint.—This method is a knee-joint disarticulation with arthrodesis of the patella to the front of the femur in its anatomic position.

It was devised to overcome some of the previous faults of stumps following disarticulation through the knee-joint.

Value of End-bearing Stumps at Knee.—The ideal stump is that which allows complete end-bearing. There are, however, many difficulties to be overcome in attaining such an ideal.

There is great difference of opinion among authorities as to the value of the end-bearing stump. Limb fitting surgeons of the British Ministry of Pensions look upon them with disfavor.

Such stumps can seldom tolerate complete end-bearing over a period of years and the long stumps are prone to circulatory disturbances and offer prosthetic difficulties. Canadian authorities, on the other hand, are enthusiastic about the value of end-bearing stumps, particularly the Gritti-Stokes. They prefer them to all other types of stumps where indicated.

From a prosthetic standpoint end-bearing-stumps offer certain disadvantages as far as fitting and wearing of prostheses are concerned, and for this reason they are not looked upon with favor by many limb manufacturers. End-bearing stumps at the knee usually are too long to be fitted with an internal knee mechanism, and therefore require outside joints which are not only bulky and unsightly but do not provide as good stability and control as the inside knee mechanism. In addition, technical difficulties are greater, as a rule, in properly performing an amputation for an end-bearing stump, and ideal conditions must exist for a successful result. The simpler an operation is, technically, the better it is suited to all conditions and to the occasional operator, and the more general will be its application. For this reason, it would seem that the simpler conventional amputations through the shaft of the bone and away from joints are to be recommended for general use.

Amputation Through the Femoral Shaft.—In amputations through the shaft of the femur, at least $2\frac{1}{2}$ inches should be allowed above the knee-joint for the fitting of the internal knee-joint mechanism of the prosthesis. Above this point as much length as possible should be saved. The ideal length is 11 inches, measured from the tip of the great trochanter. For satisfactory stump control and for efficient gait with a prosthesis, at least 9 inches of femur is desirable. In shorter stumps than this, adductor power is limited, and muscular control of the stump becomes increasingly difficult with decrease in length. Stumps shorter than the middle third of the thigh are prone to flexion and adduction contractures, making alignment and fitting of the thigh socket difficult. Stumps with less than 5 inches of femur, measured from the trochanter, cannot as a rule be fitted with the conventional type of thigh socket with pelvic suspension, because the stump will not stay within the socket during movement of the hip, but such stumps do not necessarily require a "tilting-table" prosthesis. They often can be fitted very satisfactorily with a saucer-shaped socket of molded leather or wood made over a plaster-of-Paris model of the stump. This socket is attached to the conventional type of thigh prosthesis and suspended by a pelvic belt and by a shoulder strap in addition. The shoulder strap controls extension of the shin by means of an internal knee control. No hip lock or knee lock is required as in the case of the tilting-table prosthesis.

Amputation of the Foot With Calcaneotibial Arthrodesis.—According to Boyd calcaneotibial arthrodesis obviates the expense and inconvenience incident to the use of a prosthesis.

The ankle is exposed through a curved lateral Kocher incision; the astragalus is removed and any remaining tarsal bones, with the exception of the os calcis, are also excised. The articular cartilage from the superior surface of the os calcis and from the entire mortise of the ankle joint is removed. The os calcis is then shifted anteriorly until the weight-bearing surface of the heel is directly beneath the long axis of the leg, and is accurately fitted into the ankle mortise; this necessitates removal of a portion of the sustentaculum tali. The surfaces of the os calcis in contact with the malleoli should be stripped of periosteum and cortex should be abraided. The anterior surface of the os calcis and approximately one centimeter of the contiguous bone are removed. The plantar skin flap should be sufficiently long to cover the anterior portion of the os calcis. The resulting scar passes just below the lateral malleolus and around the front of the ankle joint.

By this amputation the weight of the body is transmitted through skin and subcutaneous tissue, well-adapted by nature for weight-bearing. Although the patient's gait lacks the resiliency offered by an artificial limb, a natural, painless stump is provided.

It is difficult for a day laborer to obtain employment while wearing an artificial appliance. This operation may enable the patient to return to his former occupation without the handicap of a prosthesis.

In Chopart's amputation, the stump is usually drawn into equinus by the triceps surae, which produces a poor weight-bearing surface and frequently leads to necrosis and ulceration of the skin. Pirogoff's amputation also provides a poor weight-bearing area, as the posterior surface of the os calcis, on which the tendo achilles is inserted, is ill adapted both anatomically and physiologically for weight-bearing. Ricard introduced a valuable modification of Pirogoff's amputation, similar to the procedure described by Boyd, wherein the normal weight-

Fig. 218. Anteroposterior and lateral roentenograms showing fusion between os calcis and ankle mortise six months after operation. (Boyd, courtesy of Jour. Bone and Joint Surg.)

bearing surface of the heel was preserved. He did not, however, fuse the os calcis to the tibia. He stated: "The anterior tendons of the leg are solidly sutured to the posterior and plantar tendons in order to obtain a sling to maintain the calcaneum in good position."

For the patient who cannot afford an artificial leg, or for the laborer, Boyd's amputation with calcaneotibial arthrodesis, gives an excellent weight-bearing stump and relieves the patient of the inconvenience incident to the use of an artificial limb. The operation is more advantageous both from an anatomical and from a physiological standpoint than other amputations through the region of the ankle or the tarsus.

RECONSTRUCTIVE SURGERY IN WARTIME

Skin Grafting.—See principles outlined on p. 376. It was the experience of many surgeons in the Italian theatre of war that in attempting to save the life of the soldier who had developed gas gangrene, nothing compared with removal of infected tissue. Adequate, thorough, and careful surgery was a prerequisite to the saving of life and limb. There is no doubt that chemotherapy especially penicillin was extremely effective, but it was the opinion of many that no matter how much penicillin was given if the infected damaged tissue was not removed completely the chances for survival of life or limb were very poor.

Chronic Osteomyelitis.—For chronic, draining fistulæ resulting from osteomyelitis, excellent results have been obtained by the following method: The sinus is excised, the diseased bone curetted and chronic granulation tissue débrided. Sulfanilamide or sulfathiazol powder is then sprayed into the depths of the wound. The clean tissues are brought together in layers and the skin sutured as in any clean surgical procedure. The percentage of cases in which healing by primary intention occurs is indeed encouraging.

Bone Reconstruction.—The operations most frequently performed for the correction of poor late results are subastragalar arthrodesis, arthrodesis of the ankle joint, and bone grafting of the long bones of the lower leg for pseudarthrosis.

Tendon Reconstruction.—In war surgery it is often impossible to perform careful tendon surgery in the presence of a freshly acquired, potentially infected traumatic wound. When débridement and treatment of shock are the foremost considerations, it often is impossible to consider function as an important immediate factor. Thus, it becomes necessary to operate on a certain number of patients with old soft tissue injuries to the foot and ankle in order to restore more adequate function. In cases in which the injury was responsible for severing a nerve or nerves, tendon transplantation with or without stabilization of the bones of the foot may become necessary.

Rehabilitation.—After severe injuries to the lower leg and foot, it is important to reëstablish function of the extremity in the shortest possible time. Reconstructive surgery may be necessary in a limited number of these cases. However, one of the most important therapeutic adjuvants at this stage, is the judicious use of physical therapy.

In the first World War, physical therapy was started in the general hospitals and hospital centers of the Army of the United States in France and was most effective in reducing the length of temporary disability and the amount of permanent disability. The value of physical therapy is so well established that every preparation for the care of wounded soldiers includes it in the general plan.

CHAPTER XXII

INFECTIONS OF THE FOOT AND ANKLE

PYOGENIC infections of the foot and ankle are due chiefly to the streptococcus, staphylococcus, and gonococcus. They may involve the bones or the soft tissues or both.

Infection may result in arthritis. Metastatic infection may be caused by infections of the throat, skin, or gastro-intestinal tract. In children, osteomyelitis is fairly common. The foot and ankle seem to be vulnerable tissues for the metastatic lodgment of bacteria. The usual sequence is a sore throat, that is, anginal sepsis, next a blood stream infection, and then foci of infection in various bones or joints. The treatment of streptococcus infections includes the use of convalescent serum, commercial streptococcus serum, penicillin, streptomycin, sulfanilamide, and blood transfusions, infusions of dextrose solution, and the usual surgical procedures.

In staphylococcus infections the staphylococcus antitoxin should be given in very large doses. Sulfapyridine, blood transfusions, and infusions are also of value. When sulfanilamide or sulfapyridine is indicated, they must be given even if their administration requires the use of a stomach tube. Large doses combined with sodium bicarbonate should be given until an adequate blood-level is established. A constant bluish discoloration of the fingers and toes should not be considered alarming. I have very often put the patient in an oxygen tent temporarily.

Baker and Shands report good results in the treatment of staphylococcus infections by means of staphylococcus antitoxin and sulfathiazol.

McGinty *et al.* found that nicotinic acid relieves unpleasant symptoms due to sulfanilamide.

It is sometimes possible in chronic conditions to remove a bone such as the scaphoid, part of the os calcis, a phalanx, or a metatarsal. In gonococcus infection of the foot, there is often a superimposed streptococcus or staphylococcus infection. In addition to the routine genitourinary treatment, hyperpyrexia and the use of penicillin and streptomycin, sulfanilamide or sulfapyridine are indicated.

TUBERCULOSIS OF BONES AND JOINTS OF THE FOOT AND ANKLE

Although, especially in large cities, the frequency of bone and joint tuberculosis has been decreasing during the past twenty years, the disease is still one of the most important in orthopædic surgery.

(The reader interested in a general discussion of tuberculosis of bones and joints is referred to the standard textbooks on orthopædic surgery.)

Distribution.—Because of the influence of weight-bearing and trauma, the lower extremity is more frequently affected by tuberculosis than the upper.

Pathology.—Bone tuberculosis usually begins on the diaphyseal side of the epiphyseal line or in the synovia. The first noticeable gross change is a local hyperemia. This stage may be followed by: (1) Absorption and cure; (2) extension to the periphery of the bone with rupture through the periosteum and discharge into periarticular structures; or (3) extension into a joint.

Symptoms.—The early symptoms of tuberculosis of bones and joints of the foot and ankle are limitation of motion, muscle spasm, and limp.

Limitation of motion is due to pain, muscle rigidity, and pathological changes in the joint.

Limp occurs when any weight-bearing joint is affected.

Muscle spasm is a protective reaction of the neighboring muscles to hold the involved joint at rest.

Pain.—While tuberculosis is not primarily a painful disease, the patient may complain of local or referred pain. Night cries occur in children, usually before midnight. They are due to the pain caused by movement of the diseased joint resulting from relaxation of the muscles during sleep.

Swelling due to exudate and obliterating joint landmarks is a constant finding. Atrophy of bone and muscle is characteristic. It is due to disuse and disturbance of the nerve supply. Deformity is due to bone destruction, contraction, and contracture of soft tissues such as muscle, tendon, fascia, and joint capsule.

Tenderness to touch and sensitiveness to movement are constant. Increased joint tension is due to the exudate and infiltration of the synovia. On palpation with one or two fingers of each hand, a feeling of bogginess is noted. The local temperature may be increased.

Roentgenography.—There is no roentgen-ray finding that is absolutely typical of tuberculosis. Evidence of tuberculosis consists of haziness or clouding of the joint space, diminution of the joint space, bone atrophy with thinning of the cortex and bone destruction usually near the epiphyseal line or necrosis of the articular cartilage. While tuberculosis is not primarily a bone-producing disease, bone may be formed if a secondary infection develops, if calcification of the exudate occurs, if the disease attacks the periosteum, and if an arthrodesing operation has been performed. The diagnosis of tuberculosis is favored by the outline of an abscess in the roentgenogram.

General Symptoms.—The general symptoms are weakness, malaise, anorexia, anemia, and an afternoon rise in the temperature.

Blood examination may not be of much aid. The hemoglobin and

the number of red cells may be reduced The white cell count is reduced unless a secondary infection is present The number of lymphocytes may be increased As yet, the serological test for tuberculosis is not of much value

Tuberculin tests are usually of more value when the reactions are positive than when they are negative and of more value in the cases of young children than in those of older persons Both human and bovine tuberculins should be used The von Pirquet dermic or skin test is the best for general use, but the intradermic or Mantoux test is more accurate

Complications —The complications of tuberculosis are abscess, which if opened or allowed to rupture, is prone to result in a sinus which is very resistant to treatment, secondary infection, amyloidosis of the spleen, liver, and kidneys, especially after long-continued suppuration

Metastasis to other joints may occur Tuberculous meningitis is practically always fatal Other tuberculous foci may appear in the mediastinal, retroperitoneal and cervical nodes

Diagnosis —The diagnosis is based on the symptoms previously outlined The differential diagnosis is based on the history, including age, environment, and trauma, the physical examination, including a search for other foci, roentgenography, tuberculin tests, aspiration of the joint or abscess, biopsy, guinea-pig inoculation, and the therapeutic test of orthopædic treatment

The roentgen-ray diagnosis depends on (1) uniform thinning of the cortex (2) condensation and thickening of the periarticular structures, (3) destruction or thinning of the cartilage, (4) the absence of new bone formation, and (5) the presence of a focus of bone rarefaction, usually in the metaphysis

Aspiration, biopsy, and guinea-pig inoculation tests may be necessary

Tuberculosis, syphilis, and gonococcus infections may be indistinguishable roentgenologically

In his study of the difference in the destruction of cartilage in tuberculous and pyogenic arthritis, Phemister found that, in pyogenic arthritis, the cartilage disappears first at points of contact and greatest pressure of opposing surfaces, whereas in tuberculous arthritis, it is destroyed first in the region where it is not in contact with opposing articular surfaces

A positive diagnosis may be made only if the injection of fluid or pus or the implantation of tissue produces microscopically proved tuberculosis in a guinea-pig

The biopsy test consists of the excision of a piece of bone, cartilage, or synovia for microscopic examination Gross examination should not be relied upon Syphilitic and tuberculous specimens may look alike even under the microscope The finding of tubercle bacilli is

of great diagnostic aid. It is important to send to the laboratory a number of pieces of well-selected tissue from several parts of the joint. *Inoculation* of a guinea-pig with either fluid or tissue taken from the joint at operation should be a routine procedure.

The guinea-pig inoculation test is valuable if the reaction is positive, but is inconclusive if the reaction is negative. It has the disadvantage of requiring a period of time sometimes as long as six weeks. It is performed by injecting aspirated fluid or pus or implanting synovia, bone, or cartilage. If the guinea-pig dies, it is examined. If not, it is killed and examined at the end of six weeks.

Girdlestone found that diagnostic arthrotomy is safe only if a positive diagnosis of tuberculosis will be quickly followed by a fusion operation, and that it is dangerous only when conservative treatment will be continued despite a positive diagnosis.

Lymph Node Biopsy.—Ottolenghi claims to be able to diagnose tuberculosis of bones and joints by examining the regional lymph nodes.

Differential Diagnosis.—The most important conditions to be considered in the differential diagnosis are syphilis, osteomyelitis, epiphysitis, arthritis, and tumors.

Prognosis.—The prognosis in a case of tuberculosis of bones and joints depends on the patient's resistance, the virulence and number of the infecting organisms, the elapsed time, and the treatment. The prognosis is good if the general condition is good. A good prognosis is favored by the early application of proper treatment in an institution. It requires good nursing and medical attention by those especially qualified to treat tuberculous patients.

OCCURRENCE OF TUBERCULOSIS IN BONES OF THE FOOT*

Bone involved	Single lesions		Multiple lesions		Single and multiple lesions combined	
	Frequency of involvement	Per cent	Frequency of involvement	Per cent	Frequency of involvement	Per cent
Calcaneum	23	41.9	36	9.9	59	14.1
Astragalus	8	14.6	42	11.6	50	12.0
Metatarsal 1	12	21.9	33	9.1	45	10.8
Cuneiform 2	2	3.6	34	9.4	36	8.6
Scaphoid	0	0.0	34	9.4	34	8.1
Cuneiform 1	1	1.8	32	8.8	33	7.9
Cuboid	2	3.6	28	7.6	30	7.2
Cuneiform 3	0	0.0	30	8.3	30	7.2
Metatarsal 2	1	1.8	21	5.8	22	5.2
Metatarsal 4	1	1.8	20	5.5	21	5.0
Metatarsal 5	0	0.0	21	5.8	21	5.0
Metatarsal 3	0	0.0	18	4.9	18	4.3
Phalanx 1	2	3.6	12	3.3	14	3.4
Phalanx 2	2	3.6	2	0.6	4	0.9
Phalanx 5	1	1.8	0	0.0	1	0.2
Phalanx 3 and 4	0	0.0	0	0.0	0	0.0
Total	55 (53 cases)	100.0	363 (94 cases)	100.0	418 (147 cases)	100.0

* Miltner, L. J.: Jour. Bone and Joint Surg., vol. 18, No. 2, April, 1936

The most frequent serious complication of tuberculous joints is sinus formation with secondary infection. Streptomycin may be of value. The treatment will be discussed under the bones affected.

The treatment of tuberculous abscess includes: (1) Puncture and aspiration, which usually must be repeated, (2) injections of various antiseptic solutions, and (3) incision and evacuation. Heliotherapy and roentgenotherapy are beneficial in the treatment of a sinus.

TUBERCULOSIS OF THE ANKLE JOINT

In the ankle, tuberculosis usually involves the subastragalar or the tibio-astragalar joints. Its symptoms are: limp, limitation of movement, muscle spasm, swelling, pain, tenderness to pressure, and sensitiveness to movement. There may be an abscess. Roentgenograms may reveal destruction of bone. In the cases of young children the treatment should be non-operative. In adolescents and adults, an ankylosing operation maintaining the foot at a right angle without eversion or inversion, is the conservative method. The operations of Hibbs, Gaenslen, Campbell, and others have been recommended.

According to Gaenslen and Schneider, a good general plan for the conservative treatment of active tuberculosis of the ankle includes rest in bed for two weeks with elevation of the foot and an elastic compression bandage over cotton, followed by the application of a plaster cast extending from just below the knee to the toes. Beginning deformity can be corrected in the early period by gradual molding of the foot and maintenance of the corrected position by one or more plaster casts. Weight-bearing should be prevented by the use of crutches and elevation of the other shoe. Later, a Thomas splint, also preventing weight-bearing, may be substituted. If, after six months, there is decided improvement, a double-bar splint extending from below the knee into the shoe and a molded leather ankle support and foot plate may be substituted.

As in the treatment of tuberculosis of all other joints, general constitutional measures, exercises not involving the joint, and heliotherapy are indicated.

Prognosis.—Frequently the bones fail to unite because of inaccurate approximation, reactivation of latent infection, or the formation of a tuberculous focus elsewhere.

With regard to the treatment of children there is a difference of opinion as to the advisability of operative fusion of any joint, but recent reports of favorable results from this procedure in other joints suggest the possibility that it may yield similar results in the ankle.

Gaenslen and Schneider find the prognosis of tuberculosis of the ankle in the adult treated conservatively, to be poor. A six-months'

period will probably be sufficient to determine the efficiency of conservative treatment. When operation is performed early, it is safe to say that the patient will return to work within one or two years. Statistics show that the factor responsible for amputation and for death from tuberculosis elsewhere in the body is often conservative treatment, continued too long.

Treatment.—Campbell finds that while tuberculosis of the ankle in adults may be arrested by conservative measures in a small percentage of cases, comparatively few patients can afford prolonged treatment. After a considerable period of conservative treatment, adults frequently will submit to amputation. Such a radical operation is unnecessary as fusion of the articular surfaces will almost invariably result in a useful limb.

Fusion operation on the ankle joint consists of removing the cartilage from the component bones of the articulation and approximating the osseous surfaces.

FIG. 249.—Roentgenogram on right reveals extensive tuberculosis of the ankle joint involving the tibia, fibula and astragalus which occurred in a patient who had a tuberculous kidney, prostate, epididymis and lung. Amputation was performed through the middle of the leg. Note especially subchondral bone destruction. Compare with normal figure on left.

Technic of Kocher Operation for Tuberculosis of the Ankle.—From a point just behind the fibula and about 2 inches above the external malleolus, a vertical incision curving forward below the tip of the malleolus and extending forward on the dorsum to the lateral border of the head of the astragalus is ma [illegible] e peroneal tendons are then divided low down, below the [illegible] leolus and the portion

of the capsule divided as far as necessary to dislocate the foot completely inward so that the sole of the foot looks directly upward This gives excellent exposure of the interior of the joint which permits careful inspection and the removal of diseased synovial membrane as well as articulating surfaces of the tibia, fibula, and astragalus This entire articulating cartilage is removed without the sacrifice of any more healthy bone than is necessary Care is taken to eradicate any diseased tissue between the tibia and fibula The denuded astragalus is shaped to fit accurately into the fork of the malleoli The foot is then fixed in mid-position between valgus and varus and in slight equinus to allow for the usual height of the heel of the shoe When the astragalus cannot be saved, a tibio-calcaneal arthrodesis is performed by removing the cartilage from the superior portion of the os calcis and lower portion of the tibia In such cases it is well to set the foot backward on the tibia A snugly fitting plaster cast is applied Stiles introduces a long, square nail through the plantar surface of the heel, penetrating the os calcis, astragalus, and tibia After three weeks he removes the nail and applies a plaster cast If only the astragalus is diseased, and if it cannot be retained without danger of extension of the disease to the joints, it may be removed and the foot displaced backward

Technic of Campbell Operation —A longitudinal incision beginning about 4 inches above the ankle joint and 1 inch internal to the fibula is made downward over the lateral aspect of the ankle joint to a point on a level with the superior surface of the external cuneiform bone The superficial and deep structures are then incised, and the lower third of the tibia and the ankle joint are exposed The superior surface of the neck of the astragalus is denuded An osteoperiosteal graft about 4 inches in length is removed from the lower third of the tibia The graft together with small bone shavings from the anterior aspect of the tibia is placed over the ankle joint in close proximity to the denuded surface of the lower extremity of the tibia and the denuded surface on the neck of the astragalus A second skin incision 3 inches in length is then made over the posterior aspect of the ankle joint to the lateral aspect and parallel with the tendon of Achilles Dissection is made between the tendon of Achilles and the posterior capsule of the ankle joint, care being taken to retract the extensor hallucis tendon inward The posterior capsule of the joint is incised transversely The posterior extremity of the astragalus and the cartilage from the posterior portion of the ankle joint are removed The posterior aspect of the tibia just above the ankle joint is denuded A mass of bone is removed from the superior surface of the os calcis and placed in contact with the denuded posterior surface of the tibia and the denuded surface of the os calcis An osteoperiosteal graft may be placed also on the posterior aspect Both

period will probably be sufficient to determine the efficiency of conservative treatment. When operation is performed early, it is safe to say that the patient will return to work within one or two years. Statistics show that the factor responsible for amputation and for death from tuberculosis elsewhere in the body is often conservative treatment, continued too long.

Treatment.—Campbell finds that while tuberculosis of the ankle in adults may be arrested by conservative measures in a small percentage of cases, comparatively few patients can afford prolonged treatment. After a considerable period of conservative treatment, adults frequently will submit to amputation. Such a radical operation is unnecessary as fusion of the articular surfaces will almost invariably result in a useful limb.

Fusion operation on the ankle joint consists of removing the cartilage from the component bones of the articulation and approximating the osseous surfaces.

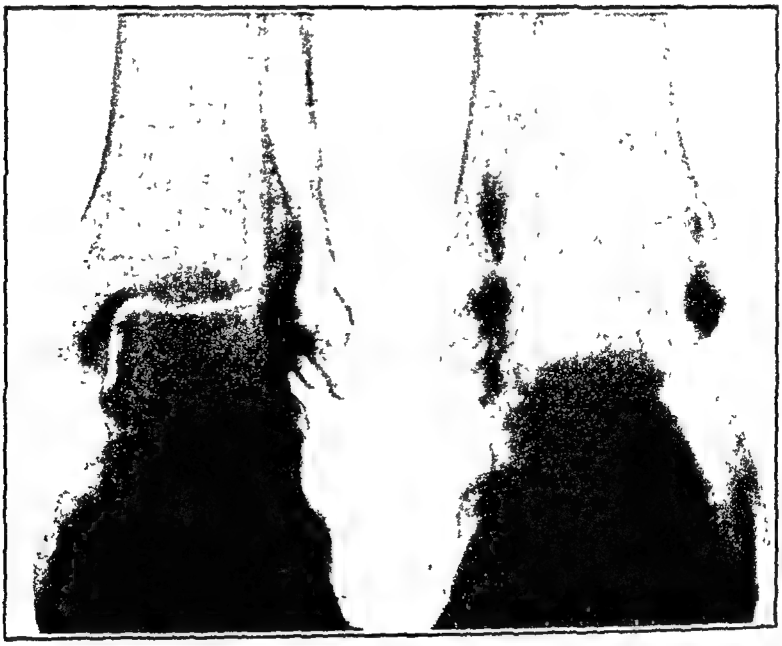


FIG 249.—Roentgenogram on right reveals extensive tuberculosis of the ankle joint involving the tibia, fibula and astragalus which occurred in a patient who had a tuberculous kidney, prostate, epididymis and lung Amputation was performed through the middle of the leg. Note especially subchondral bone destruction. Compare with normal figure on left.

Technic of Kocher Operation for Tuberculosis of the Ankle.—From a point just behind the fibula and about 2 inches above the external malleolus, a vertical incision curving forward below the tip of the malleolus and extending forward on the dorsum to the lateral border of the head of the astragalus is made. The peroneal tendons are then divided low down, below the external malleolus and the portions

of the capsule divided as far as necessary to dislocate the foot completely inward so that the sole of the foot looks directly upward. This gives excellent exposure of the interior of the joint which permits careful inspection and the removal of diseased synovial membrane as well as articulating surfaces of the tibia, fibula, and astragalus. This entire articulating cartilage is removed without the sacrifice of any more healthy bone than is necessary. Care is taken to eradicate any diseased tissue between the tibia and fibula. The denuded astragalus is shaped to fit accurately into the fork of the malleoli. The foot is then fixed in mid-position between valgus and varus and in slight equinus to allow for the usual height of the heel of the shoe. When the astragalus cannot be saved, a tibio-calcaneal arthrodesis is performed by removing the cartilage from the superior portion of the os calcis and lower portion of the tibia. In such cases it is well to set the foot backward on the tibia. A snugly fitting plaster cast is applied. Stiles introduces a long, square nail through the plantar surface of the heel, penetrating the os calcis, astragalus, and tibia. After three weeks he removes the nail and applies a plaster cast. If only the astragalus is diseased, and if it cannot be retained without danger of extension of the disease to the joints, it may be removed and the foot displaced backward.

Technic of Campbell Operation.—A longitudinal incision beginning about 4 inches above the ankle joint and 1 inch internal to the fibula is made downward over the lateral aspect of the ankle joint to a point on a level with the superior surface of the external cuneiform bone. The superficial and deep structures are then incised, and the lower third of the tibia and the ankle joint are exposed. The superior surface of the neck of the astragalus is denuded. An osteoperiosteal graft about 4 inches in length is removed from the lower third of the tibia. The graft together with small bone shavings from the anterior aspect of the tibia is placed over the ankle joint in close proximity to the denuded surface of the lower extremity of the tibia and the denuded surface on the neck of the astragalus. A second skin incision 3 inches in length is then made over the posterior aspect of the ankle joint to the lateral aspect and parallel with the tendon of Achilles. Dissection is made between the tendon of Achilles and the posterior capsule of the ankle joint, care being taken to retract the extensor hallucis tendon inward. The posterior capsule of the joint is incised transversely. The posterior extremity of the astragalus and the cartilage from the posterior portion of the ankle joint are removed. The posterior aspect of the tibia just above the ankle joint is denuded. A mass of bone is removed from the superior surface of the os calcis and placed in contact with the denuded posterior surface of the tibia and the denuded surface of the os calcis. An osteoperiosteal graft may be placed also on the posterior aspect. Both

wounds are then closed, and a plaster cast extending from the toes to just below the knee is applied to hold the foot in a position of slight equinus. When the quality of the bone on the affected side is defective, the graft may be taken from the other limb.

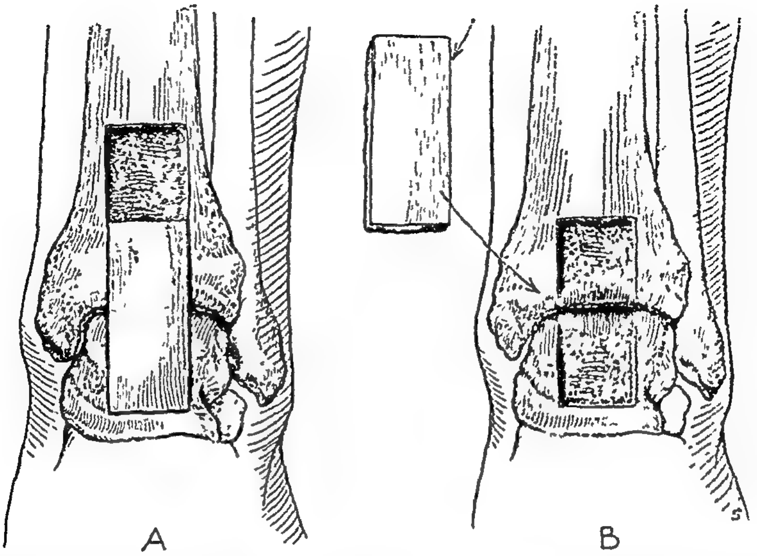


FIG. 250.—Anterior fusion of ankle. *A*, Sliding graft. *B*, Graft removed from upper portion of tibia, same dimensions as prepared bed. (Campbell's Operative Orthopedics, courtesy of C. V. Mosby Company.)

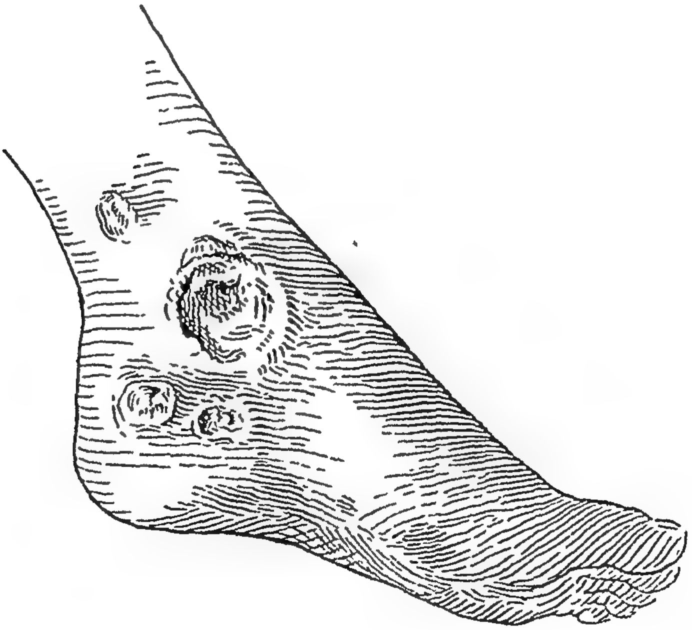


FIG. 251.—Sinuses and ulcers in tuberculosis of the ankle joint. (Drawn from a photograph.)

The cast is worn for at least three months. On its removal a leather reinforced corset is applied. Weight-bearing is permitted, but the brace

is worn until fusion is solid. A period of six months is required before osseous fusion is complete.

The most favorable time to induce fusion in tuberculous joints is the early stage or after the disease has subsided. When the process is active, with extensive destructive changes, osseous reaction is at a low ebb and there is grave danger of exaggerating the already active process or causing secondary infection. It is possible that osseous fusion may be induced by employing only the posterior route, the anterior incision and the osteoperiosteal graft being omitted. However, if an osseous bridge on both aspects can be produced, the result will be more certain.

Biesalski's Panastragaloid Arthrodesis.—This operation is recommended for adults with advanced tuberculosis of the ankle joint who might otherwise be subjected to amputation. It includes arthrodesis of the ankle and the subastragalar, astragalonavicular, and calcaneocuboid joints. Complete fusion of all these joints must be obtained.

TUBERCULOSIS OF THE BONES OF THE FOOT

In a study of the relative frequency of involvement of the bones of the foot, Miltner found that the disease involved most frequently the calcaneus, astragalus, first metatarsal, scaphoid, and first and second cuneiform bones, which bones are of first importance in transmitting weight from the tibia to the arches of the foot.

Tuberculosis of the os calcis usually occurs in the anterior portion of the body of the os calcis. It should be treated the same as pyogenic osteomyelitis.

Tuberculosis of the Tarsus.—For cases of tuberculosis of a portion of the tarsal bones and joints Geist recommends resection of the diseased area. This operation, called "anterior tarsectomy," is carried out entirely in normal tissue. The end-result is a useful, although shortened foot.

The Ollier Operation for Tuberculosis of the Anterior Tarsus.—In the Ollier operation as performed by Geist, a transverse incision is made squarely across the dorsum of the foot providing adequate exposure of both sides as well as the dorsum of the bones of the tarsal region. Blood-vessels, nerves, tendons, and muscles on the dorsum are divided. By this procedure the foot is practically skeletalized between the tarsal joints and beyond. With an amputation saw, it is then possible to cut away or remove any desired section of the tarsus extending from the neck of the astragalus up to and including the bases of the metatarsal bones. The saw cuts are made parallel. After approximation of the cut bone surfaces, the periosteum is sutured with chromic sutures. The divided tendons are reunited and the dorsalis pedis artery is ligated. The wound is then closed, and dressings and a plaster cast are applied.

In tuberculosis of the bones of the foot, radical operations, particularly amputation, are frequently required. By means of radical excision of the diseased soft tissues and bone, Miltner and Wang were able to eradicate the local disease and save a useful portion of the foot in 20 per cent of cases.

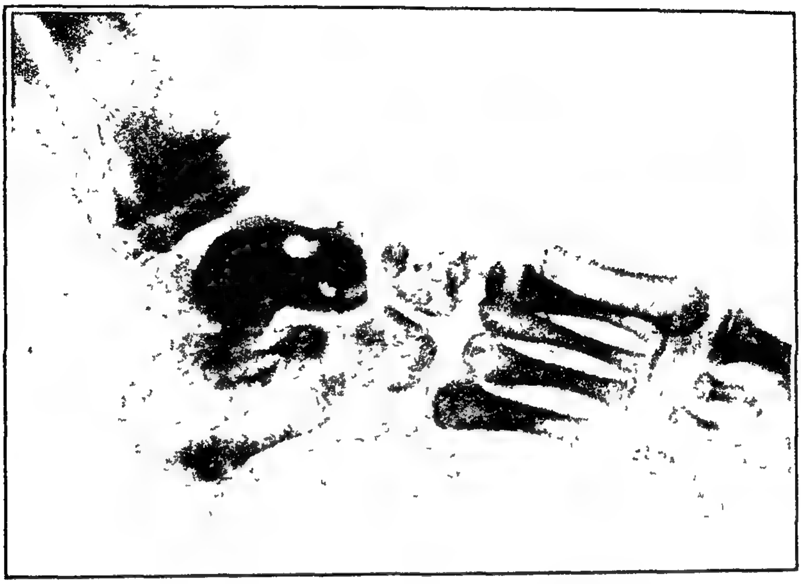


FIG 252.—Tuberculosis of astragalus, active stage.

FIG. 253.—Tuberculosis of astragalus, healing stage.

Many patients with tuberculosis of the foot who are free from active tuberculous lesions elsewhere may often become useful members of society in a few weeks' time.

In advanced cases of tuberculous lesions of the bones and soft tissues of the foot, amputation through the leg is advisable

Treatment by careful surgical excision has proved to be an excellent method of management for advanced local lesions, especially those in adults By this means it is often possible to eradicate the local disease entirely and save a useful portion of the foot Boyd's amputation may be indicated

SYPHILIS OF THE FOOT AND ANKLE

Treponema pallida infection of the bones and joints of the foot and ankle consists of periostitis, gumma, osteitis, osteomyelitis, epiphysitis, synovitis, arthritis, and the Charcot lesion

The lesions may be destructive or productive

In both congenital and acquired syphilis, periostitis frequently develops during the eruptive stage It may occur simultaneously in several bones

Diffuse periostitis produces new bone, thereby causing the bone to become greatly thickened Some spur formations on the os calcis are due to hereditary syphilis

A gumma is produced by combined destructive and constructive processes Gummas may accompany periostitis in children, but the true gummatous lesion belongs to the tertiary stage of acquired syphilis Gummatous osteitis is frequently secondary to periostitis The granulation tissue of the gumma infiltrates the bone, causing necrosis The bone may become sclerosed and thickened Osteoporosis may result and fracture may occur The healing of the fracture may not be delayed Syphilitic dactylitis is frequently mistaken for tuberculous dactylitis In syphilitic dactylitis, however, there is a disproportion between the clinical and roentgen findings The destruction may be cortical or medullary or both Pyogenic osteomyelitis frequently leads to sequestration In syphilitic osteomyelitis, sequestration is rare In the tuberculous shaft, shadows indicating destructive processes are expected In syphilis, the shaft remains clear

Christie says that syphilitic dactylitis is likely to be multiple whereas tuberculous dactylitis is likely to involve only one bone If there is sinus formation, the condition is likely to be tuberculous, whereas if periostitis is marked, it is probably syphilitic In syphilis, there is usually a good deal of swelling of the periarticular tissues accompanied by fluid in the joint

In syphilitic epiphysitis, a separation of the epiphysis may be seen Thickening of the shaft on the epiphyseal side is indicative of syphilis

Syphilitic osteomyelitis occurs most frequently at or near the ends of the long bones and may involve the epiphyses

Wassermann and Kahn tests should be made on the blood of all

patients. One negative test does not rule out syphilis. In every case of syphilis, examination of the spinal fluid is essential; it is often the only means of detecting incipient neurosyphilis. When syphilitic bone involvement is suspected, roentgenograms of the tibia and the fibula should be made.

In congenital syphilis, the family history is important but often unreliable.

FIG 254 —Syphilitic arthritis of ankle with generalized osteoporosis of bones of foot.

The bone pain of syphilis is worse at night. The first roentgen changes appear most frequently on the surface of the bone as a fuzzy proliferation of the periosteum. The periosteum has an irregular contour, and may be arranged in layers with a definite space between.

With proliferation and elevation of the periosteum over a small area, "bone blisters" may appear. Bulging of the periosteum occurs especially along the tibia. When the contour of the periosteum is destroyed, a moth-eaten or reticulated appearance supervenes. There may be proliferation of periosteum in the form of fine anastomosing trabeculæ,

forming the so-called "lace work" Parallel veiling of the shaft may occur between an osteogenetic zone of periosteum and normal bone cortex So long as there are no gummatous degenerative changes, the parallel veiling of the shaft is maintained, but as soon as the process invades the cortex proper, there is an immediate reaction with the formation of new deposits, rich in lime salts which cast shadows in sharp contrast to the roentgen appearance of the area of thinning and decalcification representing the destructive phase

When the destructive process breaks through the periosteum, an umbilicated cavity—a bone ulcer—appears in the cortex

Gummas may appear in the form of a circumscribed periostitis causing round nodes and sometimes softening and breaking down They may begin in the marrow or the spongy parts of the bone In gummatous periostitis, a moth-eaten appearance of the periosteum is characteristic A subperiosteal gumma produces a definite elevation of the periosteum under which are seen shadows of greater or lesser density due to the deposit of bone, which is characteristic of syphilis

The syphilitic bone lesion is predominantly osteoplastic Bone lesions in which destructive changes predominate are often malignant Tuberculosis and malignancy cause loss of bone salts or halisteresis Tuberculosis gives poor roentgenographic pictures on account of hypomacia, whereas syphilitic lesions produce sharp and dense shadows Opacity is characteristic of bone syphilis and probably indicates an effort toward hypertrophy Skinner finds in syphilis, that the bones seem to display a resistance to invasion by piling up a zone of defense, whereas in tuberculosis, they show resignation to the progress of the invader

Syphilis of the long bones is an osteoplastic constructive process characterized by the deposition of dense bony tissue in the cortical and periosteal zones According to Boggs, there is an irregular epiphyseal line with periosteal new bone formation on the shaft side of the epiphyseal line A classical example is the anterior hypertrophy of the tibial cortex occurring in acquired syphilis, which is called the "saber-shaped" deformity

Syphilitic osteitis may be destructive as well as constructive Characteristic of this condition are deep, well-defined local pittings of the bone Gummatous infection of bones, if localized, produces erosion and rarefaction of a limited area of the shaft of the bone with new periosteal bone formation on either side of the affected area In spongy bone, the destructive process is characterized by areas of increasing opacity, obliteration of the trabeculæ and, when the process breaks through the surface, the formation of nodular masses Bone destruction due to syphilis produces light areas surrounded by dark areas of reactive bone formation or thickening, which distinguish it from bone

tumors and tuberculosis. When a gumma surrounds an island of bone, it appears as a sequestrum. In the epiphyses, syphilitic gummas appear as small well-defined cavities.

A special type of osteomyelitis is often seen as a bilateral semilunar defect at the upper end of the tibia, immediately adjacent to or just below the epiphyseal line. According to Vogt's experience, this is pathognomonic of syphilis. When a dense narrow line is present, at the ends of the diaphysis, most cases will show also a parallel zone of diminished density just proximal to it. Serrated metaphyseal margins are characteristic.

Syphilitic Arthritis.—Syphilitic arthritis is arthritis due to syphilis—not arthritis occurring in a syphilitic subject. Todd defines syphilitic arthritis as arthritis which is due fundamentally to syphilis and is curable by antisyphilitic treatment if diagnosed fairly early. The reaction to antisyphilitic treatment is more important evidence than the Wassermann test. Monarticular arthritis of a deforming type, at any age, may be syphilitic.

Syphilis of the joints may be manifested as synovitis or osteoarthritis. In the synovial form there are no characteristic roentgenographic signs. A chronic resistant hydrops may develop.

According to Todd, the clinical characteristics of syphilitic arthritis include: (1) painlessness, in spite of profuse hydrops, especially when this is associated with a free range of movement; (2) symmetrical synovitis; (3) maintenance of the general health in spite of the prolonged joint affection; (4) failure to respond to specific drugs; (5) persistence of the condition in spite of treatment that would be successful in other conditions such as rheumatism, rheumatoid arthritis, or tuberculosis; (6) osteoscopic (bone) pain; and (7) associated evidence of syphilis. Most characteristic is the fact that pain, muscular spasm, and disability are far less marked than is to be expected from the physical and roentgenological manifestations.

Characteristic of the syphilitic joint is a high degree of destruction with or without bone production. The articular cartilage may be destroyed, and a flail joint or ankylosis with contractures may develop. There is very little pain and very little atrophy.

Diagnosis.—The diagnosis is based on the history, symptoms, physical examination, roentgenograms, and serological reactions. Wassermann and Kahn tests should be made in every case of arthritis. In every obscure case of arthritis, a joint puncture with Wassermann and Kahn tests and cytologic examination of the fluid should be made, in addition to the Wassermann test of the blood. In the tertiary stage, there are usually well-marked changes characteristic of destruction of the articular cartilages and inflammation and erosion of the underlying bones. The changes are generally proliferative at the margins of the

articular surfaces and destructive over the pressure surfaces Irregular osteophytes project from the edges of the articular surfaces

Todd finds that the following changes demonstrated by the roentgenogram are most suggestive, if not pathognomonic, of joint syphilis (1) an increase in density of one of the bones of the articulation, often with gross hypertrophy, (2) proliferation of the periosteum of one of the bones forming the articulation a short distance from the joint surface, (3) a definite punched-out area on the articular or extra-articular surface, (4) a fuzziness of the joint surface, irregular opaque areas beneath the articular surfaces, and irregular loose particles within the joints, (5) a large opaque area within the cancellous bone and a short distance from the articular surface, and (6) extensive destruction without atrophy of bone tissue unless complicated by secondary infection

Syphilis of the Bones in Children —Syphilis in infancy and childhood may be congenital or hereditary The disease usually manifests itself before the seventh year

According to McLean, syphilitic lesions of the tarsal, metatarsal, and metacarpal bones and the phalanges do not occur in the first months of life, except when the larger bones of the extremities are involved The pathologic change in the bones is usually osteochondritis or periostitis According to Shipley *et al*, the syphilitic changes in the bones of the fetus are usually confined to the epiphyseo-diaphyseal region The periosteal lesion is secondary in importance to the endochondral defect After birth, the periosteal reaction begins and may be the most striking skeletal lesion The beginning of the process is an intensification of the shadow cast by the bone at the epiphyseal line This line becomes much broader and more homogeneous, and seems to form a cap on the ends of the trabeculae of the spongiosa In the cartilage of the normal embryonic bone the provisional zone of calcification is very narrow, in the syphilitic bone, the calcified cartilage may show on section a width of from 0 5 to 1 5 mm

In its location and general character, syphilis of bones in children resembles rickets or scurvy Syphilis and rickets may coexist The 'saber tibia' due to syphilitic periostitis resembles the tibia of anterior bow-legs or rickets In syphilis, the thickening is periosteal, whereas in rickets it is endosteal Cortical thickening exists in both conditions, but in rickets it is on the concave side of the curve whereas in syphilis it is usually on the convexity Periosteal "veiling" may be of rachitic origin, but in marked syphilitic subperiosteal thickening in the first months of life metaphyseal lesions always coëxist

The most characteristic roentgen observation in bone syphilis in children is the subperiosteal multilayer "cloak" or "mantle" This may be present as the predominating lesion after the fourth month of life and is the sole active lesion after the fifth month

According to McLean, the diagnosis of syphilitic bone disease in the first months of life may be made on the basis of the roentgen evidence alone in the following types of lesions: (1) well-defined saw-tooth metaphyses in well-calcified bones; (2) deep zones of submetaphyseal rarefaction in the longitudinal axis; (3) multiple "separation of epiphyses"; (4) bilateral symmetrical osteomyelitis of the proximal mesial aspects of the tibias; (5) multiple circumscribed osteomyelitis of the long bones, shown as patchy areas of rarefaction; (6) multiple longitudinal areas of rarefaction in the shafts of the long bones, sometimes resulting in fractures; (7) destructive lesions at the mesial or lateral aspects of the metaphyses; (8) multiple areas of cortical destruction, generally seen within 1 cm. of the ends of the bones; (9) double zone rarefaction at the ends of bones; and (10) localized periosteal "cloaking" occurring in more than one bone.

Syphilis in children's bones may present a "leopard skin" appearance.

Bone Syphilis in the Second Period of Childhood.—Allende reported cases of bone syphilis in children from five to thirteen years of age. The lesions at this age are most apt to be localized in the metaphysis and cause disturbances of growth. In almost all of Allende's cases the syphilis was activated by trauma. The lesions corresponded to those of tertiary syphilis in adults. Three of the patients had diffuse gummatous osteomyelitis; 2, syphilitic hyperostosis; 1, arthritis; and 1, a white swelling with enormous enlargement of the joints and suppuration but no bone lesions demonstrable on roentgen-ray examination. One of the cases showed the "leopard skin" roentgenogram of the epiphyseal form described by Lance and Huc, but the condition had invaded the epiphysis, the metaphysis, and the joint cartilage, resembling a malignant bone tumor. In 1 case of syphilitic hyperostosis, the length and thickness of the tibia were enormously increased. In a number of cases, sequestrums were formed. Adenopathy was rare, and was generally caused by secondary infection. The infrequency of adenopathy usually differentiates the condition from tuberculosis. Biopsy of the nodes is of great aid in establishing the diagnosis. Suppuration may occur.

Treatment of Syphilis of Bones and Joints.—The drugs used include mercury, potassium iodide, bismuth, and arsenic. Mercury may be given by mouth, intramuscularly, or by inunction. The iodides are given in solution. Arsenic is administered in the form of arsphenamine and neo-arsphenamine. Malaria therapy is recommended. Hanzlik *et al.* recommended iodobismital. Penicillin is highly effective.

Care must be taken to prevent deformity. If deformity has occurred, it should be corrected.

OSTEOMYELITIS OF THE BONES OF THE FOOT AND ANKLE

Osteomyelitis is an infection of the bone marrow, by which internal pressure deprives the shaft of the bones of nutrition and causes necrosis It is primarily an intramedullary abscess

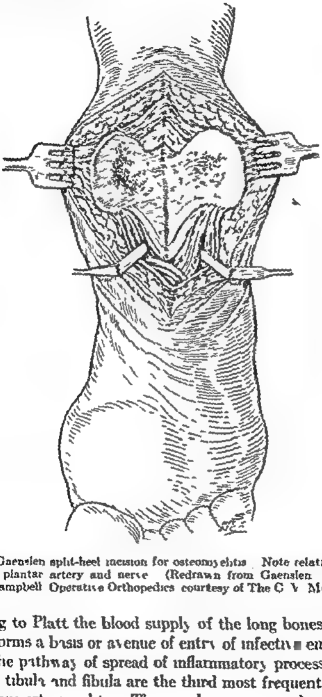


Fig 255 —Gaenslen split-heel incision for osteomyelitis Note relation of distal end of incision to plantar artery and nerve (Redrawn from Gaenslen Jour Bone and Joint Surg Campbell Operative Orthopedics courtesy of The C V Mosby Company)

According to Platt the blood supply of the long bones, first taught by Lexer, forms a basis or avenue of entry of infective emboli into the bone and the pathway of spread of inflammatory process The lower ends of the tibula and fibula are the third most frequent locations for hematogenous osteomyelitis The os calcis, metatarsals and phalanges are the most common sites for osteomyelitis of the foot

Etiology —The hematogenous form of acute osteomyelitis is the most common variety Following a local trauma the infectious agent

is brought to the bone through the blood and lymph vessels and is carried directly to the medullary canal *via* the nutrient canal. Osteomyelitis can also occur by the direct inoculation of open wounds and compound fractures.

FIG. 256.—Osteomyelitis at the distal end of first metatarsal bone.

According to Wilensky, there is an "extension" form of acute osteomyelitis in which infection of the bone structure occurs as a progressive disease, direct and continuous from and because of the continuity of its

tissue with the focus of infection in intimate anatomical relation with the bone Infection arising within the joint and causing subsequent osteomyelitis may possibly be classified under this type

The primary focus of hematogeneous osteomyelitis is usually in a distant area, such as a tonsil, the mouth and skin Although any organism may be found, the disease is usually caused by staphylococci or streptococci

The most frequent etiological factors include injury, chilling, lowered resistance, swimming, and various skin infections, such as infected blisters and furuncles Although trauma usually determines the location of the primary osteomyelitic lesion, it may have nothing to do with localization of the secondary foci

The disease is more common in children than adults because the bone in a child is less resistant and the blood supply of the diaphyses and epiphyses is richer Osteomyelitis of the bones of the foot and ankle occur twice as often in males as in females

Symptomatology —There is usually a definite history of an injury which may be in the vicinity of the ankle joint This may cause a limp for a few hours or a day After this, function may return and the patient appears apparently well until the local symptoms occur, at the site of the trauma The epiphyses of the lower end of the tibia and fibula may be traumatized by inversion or eversion of the foot According to Wilensky the tarsal bones which are most frequently affected are the calcaneus with its wide posterior epiphysis, the astragalus with its small posterior epiphysis, and the navicular with its tubercle epiphysis

To a lesser degree the metatarsals and phalanges may be liable to injury in the regions of the epiphyseal lines

The early acute state of inflammation with pressure from exudate, is accompanied by pain, swelling, redness, tenderness and toxemia This is the stage in which the danger from septicemia is greatest

It is important to be able to establish the primary cause of acute osteomyelitis A search should be made for skin lesions and foci of infection throughout the body following the acute phase

The reactive stage is the period when the tension of the exudate is relieved, either by rupture of the periosteum or by surgical intervention New bone is laid down on the under surface of the elevated periosteum forming an involucrum The opening through the periosteum persists as a cloaca which acts as an outlet for pus and bone débris The next stage is one of active phagocytosis and sequestration with removal of the bone débris

If the necrosis of the bone is believed to be a purely circulatory disturbance and not suppurative, one may assume that a bone appearing necrotic under the roentgen-ray may become revascularized

Secondary infection of the neighboring joint from osteomyelitis is not common except in the hip, although hyperemia of the joint and a serous effusion may take place. The most important objective symptom during the acute stage is a sharply defined point of tenderness situated near the epiphyseal line, with no complaint of tenderness to pressure over the surrounding area. If handled very carefully the adjacent joint can be moved freely without pain and there will be no evidence of synovitis or arthritis.

During the first twenty-four or thirty-six hours of the disease the systemic manifestations of toxemia are present. These include headache, dry tongue, malaise and sometimes vomiting. The pulse rate is commonly between 120 and 130 per minute. The temperature is from 103° to 104° and there is a polymorphonuclear leukocytosis, up to 30,000.

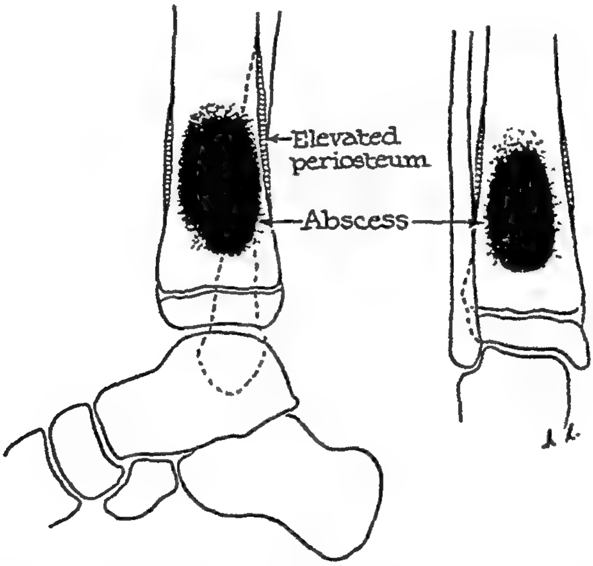


FIG. 257.—Brodie's abscess (chronic osteomyelitis) in the lower third of the tibia. Lateral and antero-posterior views Redrawn from roentgenograms.

During a later stage, swelling, redness and edema develop with an increase in the area of tenderness and toxemia. If untreated, thickening of the bone structure appears, and if the periosteum ruptures, fluctuation may be detected, with accompanying redness and swelling and periarticular swelling.

Roentgen-ray Findings.—The roentgenogram is usually negative for seven or more days after the onset of acute symptoms. The first abnormal signs noted will be a haziness in the metaphyses, with thickening due to subperiosteal new bone formation (involucrum). This will be followed by osteoporosis and destruction of the bone in the shaft.

Differential Diagnosis.—Acute rheumatic fever is a common condition for which acute osteomyelitis is mistaken. In the former the onset

of pain, tenderness and swelling are synchronous, whereas in osteomyelitis, swelling may not appear for two or three days Further, monarticular symptoms are uncommon in rheumatic fever

Acute suppurative arthritis is characterized by the fact that the symptoms are localized to the joint itself They include swelling, pain, tenderness and limitation of movement

Epiphysitis is usually osteochondritic, infectious or metabolic Metaphysitis and diaphysitis are usually infectious Infective arthritis due to the gonococcus, or pneumococcus, can be diagnosed by aspiration of the joint and culture of the fluid Other conditions that can be confused with osteomyelitis include cellulitis, soft tissue abscess, fracture, tuberculosis, syphilis, synovitis, tenosynovitis, and blood-vessel inflammations

Prognosis —The prognosis must always be guarded, particularly if a blood culture is positive The age of the patient does not seem to be a factor in recovery The most important factors in the prognosis are an early diagnosis and surgical intervention

Complications —Metastatic foci in other bones may cause serious complications, and should be watched for, during the course of treatment A localized bone abscess (Brodie's abscess) may remain as a symptomless lesion, which in some cases is diagnosed only when roentgenograms are taken Soft tissue abscess may occur Pyogenic arthritis of an adjacent joint is a rather uncommon sequel Death from septicemia may occur in cases of overwhelming septicemia The infection in the bone may remain latent for many years, and may become reactivated by slight trauma, or for no apparent reason as late as twenty to thirty years after the original infection

Treatment —The most important factor in the surgical treatment is the immediate release of tension and pus This should be done before the roentgenograms show positive findings It is accomplished by making single or multiple drill holes in the metaphysis or by carefully cutting a trapwindow in the metaphysis Although immediate treatment may be an absolute necessity in adults, the tendency in the treatment of children is to wait somewhat longer before intervening surgically, especially since the introduction of penicillin The treatment of chronic osteomyelitis has been revolutionized by the advent of chemotherapy especially the sulfa drugs and penicillin

We do not know yet what value streptomycin will have in this condition

A notable advance was made during World War II when observers rediscovered that in chronic osteomyelitis it was very helpful in many cases to do a cleaning out operation of the cavity and to implant soft tissue grafts This work was especially stimulated by Kelly, Burgess, and McClintock

Secondary infection of the neighboring joint from osteomyelitis is not common except in the hip, although hyperemia of the joint and a serous effusion may take place. The most important objective symptom during the acute stage is a sharply defined point of tenderness situated near the epiphyseal line, with no complaint of tenderness to pressure over the surrounding area. If handled very carefully the adjacent joint can be moved freely without pain and there will be no evidence of synovitis or arthritis.

During the first twenty-four or thirty-six hours of the disease the systemic manifestations of toxemia are present. These include headache, dry tongue, malaise and sometimes vomiting. The pulse rate is commonly between 120 and 130 per minute. The temperature is from 103° to 104° and there is a polymorphonuclear leukocytosis, up to 30,000.

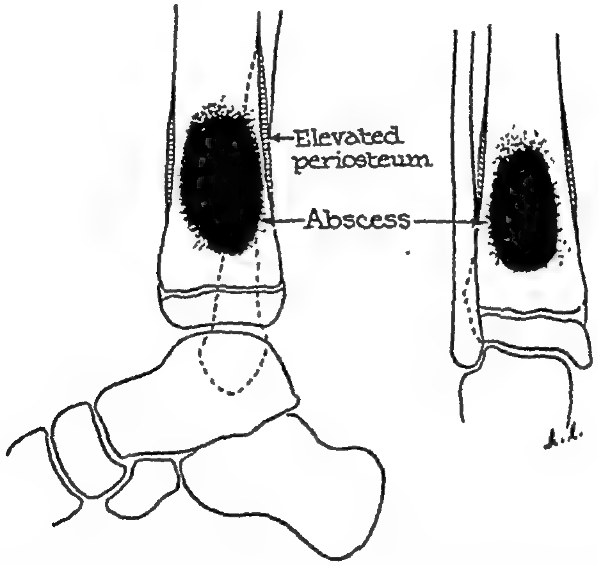


FIG. 257.—Brodie's abscess (chronic osteomyelitis) in the lower third of the tibia. Lateral and antero-posterior views. Redrawn from roentgenograms.

During a later stage, swelling, redness and edema develop with an increase in the area of tenderness and toxemia. If untreated, thickening of the bone structure appears, and if the periosteum ruptures, fluctuation may be detected, with accompanying redness and swelling and periarticular swelling.

Roentgen-ray Findings.—The roentgenogram is usually negative for seven or more days after the onset of acute symptoms. The first abnormal signs noted will be a haziness in the metaphyses, with thickening due to subperiosteal new bone formation (involucrum). This will be followed by osteoporosis and destruction of the bone in the shaft.

Differential Diagnosis.—Acute rheumatic fever is a common condition for which acute osteomyelitis is mistaken. In the former the onset

of pain, tenderness and swelling are synchronous, whereas in osteomyelitis, swelling may not appear for two or three days Further, monarticular symptoms are uncommon in rheumatic fever

Acute suppurative arthritis is characterized by the fact that the symptoms are localized to the joint itself They include swelling, pain, tenderness and limitation of movement

Epiphysitis is usually osteochondritic, infectious or metabolic Metaphysitis and diaphysitis are usually infectious Infective arthritis due to the gonococcus, or pneumococcus, can be diagnosed by aspiration of the joint and culture of the fluid Other conditions that can be confused with osteomyelitis include cellulitis, soft tissue abscess, fracture, tuberculosis, syphilis, synovitis, tenosynovitis, and blood-vessel inflammations

Prognosis —The prognosis must always be guarded, particularly if a blood culture is positive The age of the patient does not seem to be a factor in recovery The most important factors in the prognosis are an early diagnosis and surgical intervention

Complications —Metastatic foci in other bones may cause serious complications, and should be watched for, during the course of treatment A localized bone abscess (Brodie's abscess) may remain as a symptomless lesion, which in some cases is diagnosed only when roentgenograms are taken Soft tissue abscess may occur Pyogenic arthritis of an adjacent joint is a rather uncommon sequel Death from septicemia may occur in cases of overwhelming septicemia The infection in the bone may remain latent for many years, and may become reactivated by slight trauma, or for no apparent reason as late as twenty to thirty years after the original infection

Treatment —The most important factor in the surgical treatment is the immediate release of tension and pus This should be done before the roentgenograms show positive findings It is accomplished by making single or multiple drill holes in the metaphysis or by carefully cutting a trapwindow in the metaphysis Although immediate treatment may be an absolute necessity in adults, the tendency in the treatment of children is to wait somewhat longer before intervening surgically, especially since the introduction of penicillin The treatment of chronic osteomyelitis has been revolutionized by the advent of chemotherapy especially the sulfa drugs and penicillin

We do not know yet what value streptomycin will have in this condition

A notable advance was made during World War II when observers rediscovered that in chronic osteomyelitis it was very helpful in many cases to do a cleaning out operation of the cavity and to implant soft tissue grafts This work was especially stimulated by Kelly, Burgess and McClintock

Secondary infection of the neighboring joint from osteomyelitis is not common except in the hip, although hyperemia of the joint and a serous effusion may take place. The most important objective symptom during the acute stage is a sharply defined point of tenderness situated near the epiphyseal line, with no complaint of tenderness to pressure over the surrounding area. If handled very carefully the adjacent joint can be moved freely without pain and there will be no evidence of synovitis or arthritis.

During the first twenty-four or thirty-six hours of the disease the systemic manifestations of toxemia are present. These include headache, dry tongue, malaise and sometimes vomiting. The pulse rate is commonly between 120 and 130 per minute. The temperature is from 103° to 104° and there is a polymorphonuclear leukocytosis, up to 30,000.

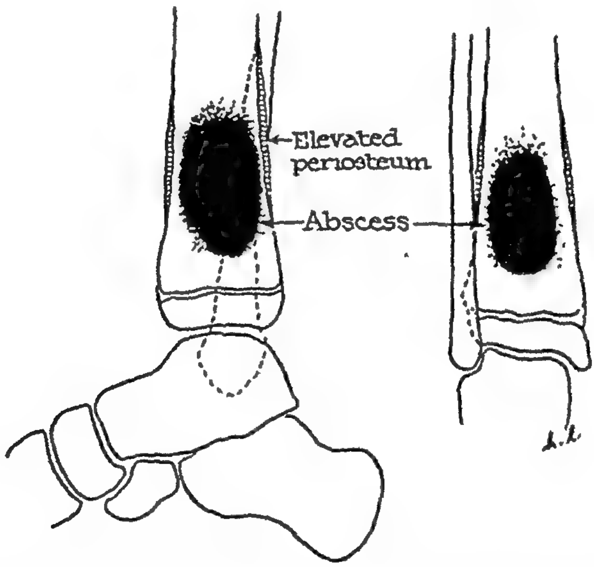


FIG 257.—Brodie's abscess (chronic osteomyelitis) in the lower third of the tibia Lateral and antero-posterior views Redrawn from roentgenograms.

During a later stage, swelling, redness and edema develop with an increase in the area of tenderness and toxemia. If untreated, thickening of the bone structure appears, and if the periosteum ruptures, fluctuation may be detected, with accompanying redness and swelling and periarticular swelling.

Roentgen-ray Findings.—The roentgenogram is usually negative for seven or more days after the onset of acute symptoms. The first abnormal signs noted will be a haziness in the metaphyses, with thickening due to subperiosteal new bone formation (involucrum). This will be followed by osteoporosis and destruction of the bone in the shaft.

Differential Diagnosis.—Acute rheumatic fever is a common condition for which acute osteomyelitis is mistaken. In the former the onset

of pain, tenderness and swelling are synchronous, whereas in osteomyelitis, swelling may not appear for two or three days Further, monarticular symptoms are uncommon in rheumatic fever

Acute suppurative arthritis is characterized by the fact that the symptoms are localized to the joint itself They include swelling, pain, tenderness and limitation of movement

Epiphysitis is usually osteochondritic, infectious or metabolic Metaphysitis and diaphysitis are usually infectious Infective arthritis due to the gonococcus, or pneumococcus, can be diagnosed by aspiration of the joint and culture of the fluid Other conditions that can be confused with osteomyelitis include cellulitis, soft tissue abscess, fracture, tuberculosis, syphilis, synovitis, tenosynovitis, and blood-vessel inflammations

Prognosis —The prognosis must always be guarded, particularly if a blood culture is positive The age of the patient does not seem to be a factor in recovery The most important factors in the prognosis are an early diagnosis and surgical intervention

Complications —Metastatic foci in other bones may cause serious complications, and should be watched for, during the course of treatment A localized bone abscess (Brodie's abscess) may remain as a symptomless lesion, which in some cases is diagnosed only when roentgenograms are taken Soft tissue abscess may occur Pyogenic arthritis of an adjacent joint is a rather uncommon sequel Death from septicemia may occur in cases of overwhelming septicemia The infection in the bone may remain latent for many years, and may become reactivated by slight trauma, or for no apparent reason as late as twenty to thirty years after the original infection

Treatment —The most important factor in the surgical treatment is the immediate release of tension and pus This should be done before the roentgenograms show positive findings It is accomplished by making single or multiple drill holes in the metaphysis or by carefully cutting a trapwindow in the metaphysis Although immediate treatment may be an absolute necessity in adults, the tendency in the treatment of children is to wait somewhat longer before intervening surgically, especially since the introduction of penicillin The treatment of chronic osteomyelitis has been revolutionized by the advent of chemotherapy especially the sulfa drugs and penicillin

We do not know yet what value streptomycin will have in this condition

A notable advance was made during World War II when observers rediscovered that in chronic osteomyelitis it was very helpful in many cases to do a cleaning out operation of the cavity and to implant soft tissue grafts This work was especially stimulated by Kelly, Burgess and McClintock

Rules of Treatment
1. Give large doses of penicillin
2. Combat systemic toxemia
3. Give blood transfusion (if possible from donor who has had osteomyelitis)
4. Do not wait for a positive roentgenogram
5. Perform early operation when indicated
6. Use a tourniquet
7. Use gentleness in operating
8. Use motor-driven instruments
9. Do not overstrip periosteum from bone
10. Do not radically remove infected marrow with a sharp curette
11. Immobilize in a splint or cast without a window
12. Warn parents of the possibility of growth disturbances
13. Use gentle traction where indicated
14. Prevent deformity
15. Guard against dislocation
16. Guard against fracture

In the treatment of chronic osteomyelitis, two methods should be mentioned.

1. The Orr method which includes good surgery, vaseline pack and a plaster-of-Paris cast. No sutures are inserted as a rule.

2. The Baer method, which is the treatment by means of maggots.

Osteomyelitis of the Os Calcis.—Despite the many methods devised for treating osteomyelitis of the os calcis, it is difficult to cure this condition completely. Rather than subject such a patient to an almost interminable period of disability, it might be wiser to remove the os calcis completely, or do a lower leg amputation. Some believe that as long as a good plantar fat pad is maintained under the heel, attempts at conservative management should be continued.

Chronic Osteomyelitis.—While the outlook in the treatment of acute osteomyelitis of the foot presents a much brighter picture since the advent of the sulfonamides and penicillin, that in chronic osteomyelitis is still not so favorable. Bacteriostatic and bactericidal agents which must reach the involved bone by way of the blood stream are blocked by barriers of avascular tissues and require surgery. Progress made in this field have been immeasurably enhanced by the availability of potent chemotherapeutic agents. Surgical procedures may now be carried out with impunity, which without their use would entail great hazard to life and limb.

No differentiation will be made between chronic osteomyelitis representing the end stage of an acute hematogenous infection of the foot and that which may follow infected compound fractures or other bone infection derived exogenously. The problem is essentially the

same and the vast experience gained during World War II in the handling of chronic bone suppuration is applicable no matter what the source of the original infection

Chronic bone suppuration with its attendant draining sinuses and retained sequestra has always presented a distressing problem in treatment directed toward eradicating the infection Unless this is accomplished, drainage may persist for years with periods of complete or relative quiescence followed by recurrence The attendant complications are ankylosis or stiffening of joints, atrophy of muscles, general disability with varying grades of secondary anemia and amyloid degeneration In some cases the bone involvement is so widespread and disability so great that amputation is the only logical recourse to the end that the patient may be returned to a useful existence The application of chemotherapy in the form of sulfa drugs and penicillin has been disappointing This was to be expected from the nature of the lesion Chronically infected bone with its sinus tracts, dense areas of scar tissue, abscesses lined by chronic granulation tissue and surrounded by areas of eburnated bone, presents a relatively avascular structure which cannot be effectively reached by substances introduced into the general circulation However, the experience of many in World War II has shown that chemotherapy is effective if locally one can establish free access to the general circulation and further provide conditions which prevent or mitigate against reinfection from without

The problem of treatment resolves itself along the following lines

1 Wide excision of the involved area including sinus tract, scar tissue, sequestra, and eburnated bone down to healthy vascular bone

2 Early obliteration of the defect created and/or closure of the wound

3 Application of chemotherapy before, during and after surgery

Wide Excision of the Involved Area —The depth of a sinus tract may be shown by inserting a flexible probe

The ramification and extent of sinus tracts may be visualized on roentgen-ray by the use of radio-opaque oil Methylene blue may be used at the time of operation by injection into the tract The stained areas will serve as a guide to the extent of excision A pneumatic tourniquet is used for hemostasis A liberal incision is made to expose the involved area included for excision of surface scars All infected and scarred tissues are removed and the bone chiseled away until vascular bone is encountered The shape of the defect left should depend on the contemplated methods of secondary closure Whenever possible the infected area should be excised *en bloc* with as little stripping of normal periosteum as possible After excision has been completed the tourniquet is released and hemostasis secured At this

point it is advisable to loosely pack the wound with vaseline gauze and immobilize the limb in a cast including the entire foot and leg. Upon occasion I have sprinkled all interstices of the wound with penicillin or sulfathiazole powder in the proportion of 10 grams of sulfa to 50,000 units of penicillin before proceeding with the dressing. In some instances the wound has been loosely packed with plain gauze and a Dakin tube incorporated so that the area could be irrigated 3 or 4 times daily with calcium penicillin solution of 250 units per cc. concentration.

Dressings are not disturbed for a period of seven to ten days following which the wound is inspected and a method of closure determined.

Obliteration of the Defect, and/or Closure of the Wound.—In 1941 Dickson, Diveley, and Kiene gave great impetus to the idea of primary closure of the wound following thorough débridement. The patient received sulfathiazole for five days preoperatively and sulfa drug was liberally dusted into the wound before closure. (1 to 2 grams using a nasal insufflator.) The administration of the sulfa drug was continued for an average of about 15 days postoperatively. Of the 18 cases, 14 closed in one to two weeks. With the advent of penicillin this method of treatment has received even greater impetus. Following excision and débridement, a certain proportion of cases will lend themselves to primary approximation of the wound edges. When this type of closure is contemplated, the débridement must be in the nature of a saucerization, if a dead space is to be eliminated. At times such closure may be made possible by relaxing incisions on either side of the wound and the resulting lateral skin defects closed by split thickness skin grafts. Before closure, penicillin-sulfa powder may be dusted into the wound as outlined above. A small drain may be used for a few days. A compression dressing is applied and the limb put at rest in a plaster splint. While this method is quite feasible and in a good percentage of cases, successful, it is safer to delay closure following débridement, for a period of seven to ten days. The wound is dressed at the end of this period and if clean granulating tissue is encountered, closure may be done the following day, or if need be, the wound further revised to insure ultimate closure.

In 1935, Lord called attention to the feasibility of closing osteomyelitic cavities by plastic methods. Following excision of scar tissue he used plastic flaps to close the defect primarily. It was his custom also to turn down flaps of muscle, fascia, or fat into the cavity. He then closed the skin over all, in one procedure. In some instances as in tibial defects the skin flaps were sunk into the cavity and the skin edges fastened by means of carpet tacks or brads. Tubes were brought

out through the wound for Dakinization By these methods he secured delayed primary healing

This type of procedure has found wide application with the advent of chemotherapy not only in the manner advocated by Dickson and his associates, but also in the exteriorization and obliteration of bone cavities

Exteriorization of osteomyelitis cavities following débridement by means of direct application of split thickness skin grafts has been extensively used during World War II and has proved to be a reliable method of dealing with defects which did not lend themselves to delayed primary closure or the shifting of skin flaps Following debridement and saucerization, a petrolatum pack dressing and cast are used for a period of seven to ten days following which the wound is dressed

If a clean granulating bed presents itself, a split thickness skin graft is applied to the wound surface and sutured into place The graft is perforated to allow for drainage and a pressure dressing applied over a protective layer of petrolatum or Xeroform gauze The limb is immobilized in plaster to insure rest and to obviate disturbing the graft In a week or ten days the area is again dressed By such exteriorization, many draining wounds incident to osteomyelitis attending missile inflicted compound fractures, can be effectively dealt with in a much shorter time than is required with previous methods

Recent reports by Prigge and Coleman and their associates have dealt with the obliteration of bone cavities subsequent to the débridement of chronic osteomyelitis by means of cancellous iliac bone implants or muscle transplants These authors have shown that following the extirpation of all avascular tissues from the infected bone, a receptive field is produced which with the addition of chemotherapy will permit the healing in of cancellous iliac bone Prigge emphasizes that whenever possible, a muscle flap transplant is preferable and will give greater assurance of healing

Shallow defects are obliterated by displacement of the adjacent muscles Deeper hollows are dealt with by suturing a muscle flap into the depths of the defect With a good vascular muscle flap coapted to a vascular bone bed and with adequate chemotherapy, conditions for healing may be secured

It can be stated that foci of chronic osteomyelitis can be dealt with effectively by the elimination of avascular and infected tissue and early obliteration, and/or closure of the resulting defect

Not every chronic osteomyelitis can be dealt with by the methods outlined Some cases are so extensive as to resist any surgical procedure except amputation and as Key pointed out, such a solution may be desirable in the presence of great disability and deformity

THE ORR METHOD

1. Preliminary

(a) Secure best position of the injured limb possible by traction or manipulation.
(b) Use the simplest movements in reducing fractures or in correcting deformities.
(c) Employ moleskin traction, pins, or ice tongs if necessary, included in the cast to maintain length and correct position.
(d) Do not move or manipulate inflamed or injured parts during or following the operation.

2. The Operation

(a) Make an incision or opening that will thoroughly uncover the infected area.
(b) Remove foreign material and dead or dying tissue.
(c) Do not curette or damage healing and protective portions of the wound cavity.
(d) Do not remove bony or soft parts that may contribute to repair.
(e) Wipe out with iodine and alcohol.

3. The Closure

(a) Fill cavity with a petrolatum gauze pack from the depths to the surface of the wound. Pack gently but firmly.
(b) Use no drainage tubes or other mechanical irritants in the wound.
(c) Use no chemical as a dressing at any time.
(d) Do not suture or cover any infected area with flaps of muscle, fascia or skin.
(e) Cover with a dry sterile, absorbent pad to take up drainage at the edges of the petrolatum pad.

4. The Splint

(a) Maintain the length and position already obtained and immobilize the affected part in such a manner that no muscle spasm or contracture can occur.
(b) Plaster-of-Paris, well fitting and extensive has been found to be most satisfactory as an immobilizing device. Its efficiency has been greatly improved by the following plan.
(c) Moleskin adhesive straps or skeletal fixation devices to be included in the cast will insure fixed traction, control of fracture fragments, and comfort for the patient.

5. The Dressing

(a) Plaster-of-Paris casts are applied so as not to be fenestrated or split. In this way the temptation to inspect or dress the wound is prevented.
(b) Secondary dressings should be done in the operating room and aseptically.
(c) The injured part is not to be moved nor the wound surface to be damaged.
(d) Do not hesitate to employ anesthetics for secondary dressings.
(e) Make late dressings as infrequently as early ones.

Chemotherapy Before, During, and After Surgery—No hard and fast rules can be laid down but in general we have found that the following plan of treatment is adequate. Penicillin is given in doses of 30,000 units every three hours for a period of five days preoperatively. Upon return from the operating room we administer 50,000 units intravenously in saline. This is followed by 30,000 units intramuscularly every three hours for a period of three to five days postoperatively, being guided by the temperature reaction and blood count.

Penicillin and sulfathiazole powder is used locally following débridement in proportion of 10 grams of sulfa drug to 150,000 units of penicillin. Where irrigation of the wound is deemed advisable postoperatively this is done through a tube leading into the gauze pack. A solution of calcium penicillin in distilled water is used. In certain cases a penicillin fast organism may be encountered which will readily respond to a sulfa drug. In such cases sulfadiazine may be used. Frequently it is advisable to administer both drugs.

It must also be remembered that an optimal time for surgery must be sought. Toward this end the general condition of the patient must be brought up to the best possible level. Blood transfusions should be given to bring up the red cell count and hemoglobin. Where the patient's nutrition is deficient an adequate intake should be assured, by the parenteral route if necessary.

Protein hydrolysates are available for intravenous administration. An adequate vitamin intake is necessary for the patient's general well-being for bone repair, and capillary formation. A high vitamin, high caloric diet is the rule when the patient can take it. The surgery of chronic osteomyelitis is not urgent surgery and the time spent bringing the patient up to an optimum level is well spent.

BONE LESIONS CAUSED BY PATHOGENIC FUNGI

Pathogenic fungi may cause infections of the bones, joints and soft tissues of the foot and ankle. Infectious granulomas are frequently due to pathogenic fungi, such as blastomycosis, coccidioidal granuloma, actinomycosis, mycetoma and torulosis. Because of their comparative rarity and resemblance clinically and roentgenographically to more common infections they are frequently overlooked. Diagnosis, by the recognition of the organism, frequently comes as a surprise.

Osseous involvement is predominantly destructive. Margins of lesions may be "punched out" or diffused. Bone production is variable. Productive periostitis may occur with superficial involvement of bone. Joints are usually involved from adjacent infection of bone or soft tissue. Actinomycosis is frequently primary about the mouth and in the gastro-intestinal tract, particularly at the cecum, while coccidioidal

granuloma has a few primary invasions of the oral region and none in the lower gastro-intestinal tract.

Skeletal mycotic infections resemble each other more than the common infections: tuberculosis, pyogenic infection and syphilis. They resemble tuberculosis more closely than the other two. Coccidioidal granuloma and blastomycosis are similar.

FIG. 258.—Gunshot wound of foot resulting in osteomyelitis. Note complete fusion of astragalus and os calcis and cuboid.

Blastomycosis.—Blastomycosis of the bones is usually a local manifestation of systematic blastomycosis, and local therapy, such as excision, is not sufficient. A complement deviation test might prove of value in diagnosis, and autogenous vaccine in therapy. Tuberculosis, coccidioidal granuloma, and blastomycosis produce similar pathological changes. The possibility of blastomycosis should be considered in all chronic osteomyelitic lesions and the pus examined for blastomycetes.

Blastomycosis of bone occurs as a primary infection, or secondary to lesions elsewhere in the body, usually in the skin or the lungs. Clinically, the disease may resemble acute osteomyelitis at the onset, and chronic osteomyelitis and tuberculosis after it has become chronic.

Actinomycosis.—Actinomycosis bovis is very rare but should be borne in mind in all cases of an inflammatory process. The diagnosis can be verified by finding the characteristic sulfur granules in pus from an abscess or sinus.

Coccidioidal Granuloma.—Coccidioidal granuloma or coccidiosis is a chronic specific infectious lesion caused by a yeast-like mold known as Coccidioides immitis. It bears close clinical and pathological resemblance to blastomycosis. The two diseases can be differentiated only

by culture as each has definite characteristics The blastomyces show definite "budding," whereas coccidioides produce endospores The disease is prone to develop in laborers who have lived in the San Joaquin Valley, California The disease usually starts in the skin of the feet and hands and produces papules, nodules and later ulcers which break down The lesions are similar to those of tuberculosis and syphilis The findings from both the pathological and roentgenological standpoints are similar to those in tuberculosis The nodules, according to Hektoen, cannot be differentiated histopathologically from those of tuberculosis

FIG 269 —Atrophy following injury Note tibial epiphysis

There have been a few reported recoveries, in every case of which the lesions were in the extremities and an amputation was performed My patient's life was saved by amputation which was followed by a complete recovery

Observers in California, who have had the most experience with this disease, have had their best results with roentgen treatment, tartar emetic intravenously, colloidal copper solutions intramuscularly and a filtrate made from the organism, called "coccidioidin"

Mycetoma—Mycetoma of the foot, known also as "Madura foot" and "fungus foot," is characterized by chronic, destructive, ulcerative lesions It occurs most commonly in India, particularly Madura There

granuloma has a few primary invasions of the oral region and none in the lower gastro-intestinal tract.

Skeletal mycotic infections resemble each other more than the common infections: tuberculosis, pyogenic infection and syphilis. They resemble tuberculosis more closely than the other two. Coccidioidal granuloma and blastomycosis are similar.

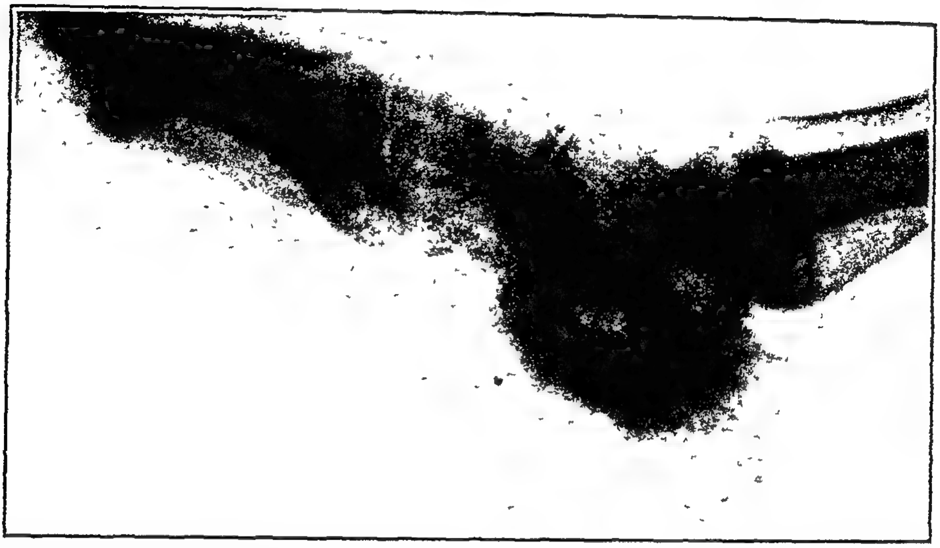


Fig. 258.—Gunshot wound of foot resulting in osteomyelitis. Note complete fusion of astragalus and os calcis and cuboid.

Blastomycosis.—Blastomycosis of the bones is usually a local manifestation of systematic blastomycosis, and local therapy, such as excision, is not sufficient. A complement deviation test might prove of value in diagnosis, and autogenous vaccine in therapy. Tuberculosis, coccidioidal granuloma, and blastomycosis produce similar pathological changes. The possibility of blastomycosis should be considered in all chronic osteomyelitic lesions and the pus examined for blastomycetes.

Blastomycosis of bone occurs as a primary infection, or secondary to lesions elsewhere in the body, usually in the skin or the lungs. Clinically, the disease may resemble acute osteomyelitis at the onset, and chronic osteomyelitis and tuberculosis after it has become chronic.

Actinomycosis.—Actinomycosis bovis is very rare but should be borne in mind in all cases of an inflammatory process. The diagnosis can be verified by finding the characteristic sulfur granules in pus from an abscess or sinus.

Coccidioidal Granuloma.—Coccidioidal granuloma or coccidiosis is a chronic specific infectious lesion caused by a yeast-like mold known as Coccidioides immitis. It bears close clinical and pathological resemblance to blastomycosis. The two diseases can be differentiated only

by culture as each has definite characteristics The blastomyces show definite "budding," whereas coccidioides produce endospores The disease *is prone to develop in* laborers who have lived in the San Joaquin Valley, California The disease usually starts in the skin of the feet and hands and produces papules, nodules and later ulcers which break down The lesions are similar to those of tuberculosis and syphilis The findings from both the pathological and roentgenological standpoints are similar to those in tuberculosis The nodules, according to Hektoen, cannot be *differentiated histopathologically* from those of tuberculosis

Fig 209 — Atrophy following injury Note tibial epiphysis

There have been a few reported recoveries, in every case of which *the lesions were in the* extremities and an amputation was performed My patient's life was saved by amputation which was followed by a complete recovery

Observers in California, who have had the most experience with this disease, have had their best results with roentgen treatment, tartar emetic intravenously, colloidal copper solutions intramuscularly and a filtrate made from the organism, called "coccidioidin"

Mycetoma.—Mycetoma of the foot known also as "Madura foot" and "fungus foot," is characterized by chronic, destructive, ulcerative lesions It occurs most commonly in India, particularly Madura There

Fig. 260.—Periostitis of post metatarsal in a trench-foot case. (Courtesy of Shumaker and Abramson.)

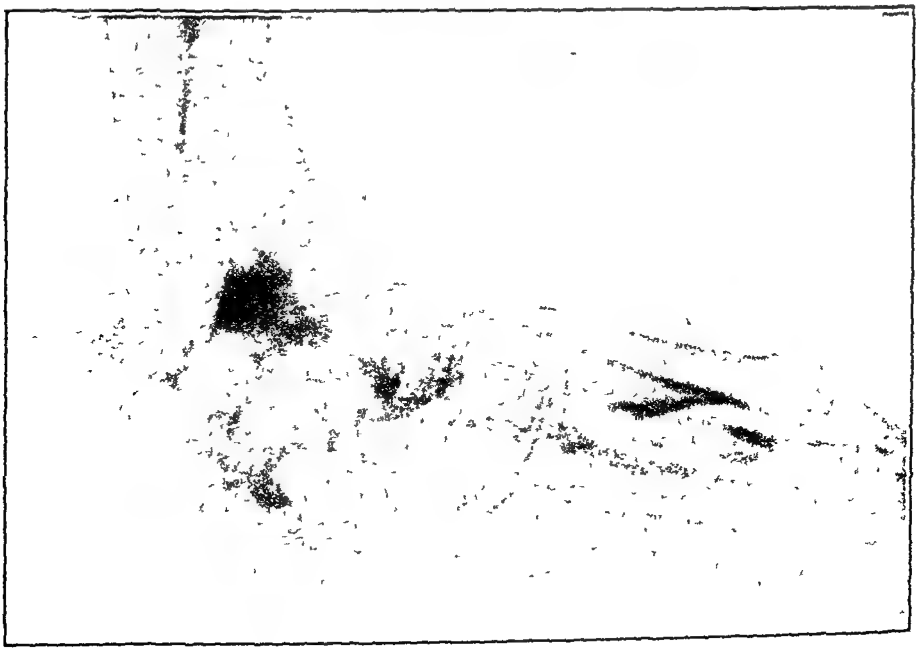


Fig. 261—Osteomyelitis of os calcis, astragalus, tibia and fibula

have been few cases in America and Europe The fungus probably grows upon grain and is contracted most frequently by those who work barefoot in the fields Mycetoma begins with the formation in the skin and subcutaneous tissues of indolent nodules similar to those of actino-

Fig 202 —Osteomyelitis of os calcis with a sinus indicated by probe Note metallic fragments A good functional result was obtained

Fig 203 —Osteomyelitis of proximal phalanx of great toe

mycosis, which break down and form sinuses. With the break-down of an increasing number of nodules, large ulcerative fungoid areas riddled with sinuses are formed. The lesion causes marked swelling and distortion. The sinuses discharge black, yellow, and reddish granules. It is chiefly upon these findings that the diagnosis is based. The treatment is usually symptomatic, but in the progressive type, amputation is advisable.

FIG. 264 —Mycetoma of twenty years duration. *Actinomyces guemai.* (Courtesy of Dr. Leon Avilla, San Salvador.)

LEPROSY

Leprosy is a chronic disease which affects skin, nerves, and bones. It was prevalent in Egypt over 2000 years B.C. The number of lepers in the world today has been estimated at from one to four millions.

The cause of leprosy was discovered, by Hansen in 1871, to be an acid-fast bacillus. Shiga announced that he had succeeded in cultivating the bacillus artificially. Dostal claimed he produced a curative serum.

The three types of leprosy are the nodular, macular, and anesthetic. Leprous osteomyelitis affects the bones of the hands and feet almost exclusively.

According to McKinley and Soule, two of the characteristics of the disease are osteoporosis and a low calcium content of the blood. The

symptoms and roentgenographic findings are similar to those of tuberculosis The changes occur chiefly in the phalanges of the hands and feet, where there is disintegration of the epiphyses and diaphyses Unless there is a secondary infection, the lesion has a very slow, insidious growth Usually there is necrosis of bone, suppuration may follow with sinus formation and secondary infection Gangrene may occur Perforating ulcers appear on the foot

Contrary to the prevailing opinion, the disease does not cause amputation The bones undergo a process of osteoporosis, they crumble, and amputation is suggested by the resulting contraction of the soft tissues

The neurological symptoms noted in from 60 to 75 per cent of cases may be primary or late A prominent symptom is anesthesia, accompanied by contractures and early atrophy In the peripheral lesions there are joint changes and pathological dislocations The cartilage is destroyed White described 2 cases of non-syphilitic Charcot joints in leprosy An individual lesion might resemble coccidioidal granuloma closely The very chronic course of leprosy, alternating improvement and advancement, and the associated trophic changes of "nicking," "slicing," "collar-buttoning" or gradual disappearance of terminal phalanges is unlike that found in pyogenic infections and the mycoses

At the National Leprosarium at Carville, Louisiana, more than 300 lepers are under treatment As regards food, fresh air, and rest, all of the patients follow a sanatorium régime which is almost identical with that prevailing in tuberculosis hospitals The treatment consists of rest in bed and proper care of all types rather than the exclusive use of a specific, such as chaulmoogra oil

TROPICAL DISEASES AFFECTING FOOT AND ANKLE

1 Fungus infections, athlete's foot and prickly heat of the skin of the foot are much more common in tropics, according to Saphir, than in temperate climates Symptomatology and treatment are the same

2 Tropical ulcers of unknown origin, are usually located around the ankle, foot, or tibia The etiology is unknown It starts with blister formation which ruptures and rapidly develops into a sloughing progressing ulcer It may attack tendons and ligaments, if deep enough Symptomatic treatment includes removal to a temperate climate

3 Yaws, caused by Spirocheta pertenue, can be demonstrated in lesions which are frequently located around the sole of the foot and ankle If ulcerative lesions are located on the sole, they are also termed "foot yaws" or "crab yaws" The Wassermann test is positive Treatment includes arsenicals and penicillin

4 Oriental sore, or Delhi boil, or Aleppo boil, are synonymous with

cutaneous leishmaniasis occurring on various parts of the body, frequently affecting the foot and ankle; painful, slowly progressing ulcerative and sloughing lesion, the smear of which may demonstrate the parasite Leishmania tropica. Transmission takes place through the bite of the infected phlebotomus (sandfly). The treatment includes Fuadin or other Antimony preparations.

5. Pinta is a contagious fungus disease of skin which may affect the feet.

6. Lepra is mentioned by name only.

7. Madura Foot is a fungus disease caused by mycetoma which produces slowly progressing ulcerative lesion of foot, leading to numerous discharging sinuses and marked enlargement and deformity. Secondary infection frequently takes place necessitating amputation. If untreated it terminates in death from sepsis and exhaustion. The treatment includes potassium iodide and the sulfonamides.

8. Mossy Foot, which produces symptomatology similar to that of Madura Foot, is caused by the blastomycosis fungus.

YAWS

The problem of endemic yaws faces every medical officer in charge of native troops in West and East Africa, Ceylon, parts of India, the East Indies, and other parts of the world. Yaws is a cause of cracked and painful feet; it is said to play a role in that medical conundrum, the "tropical ulcer," and according to Helfet it is the most common disease of bones and joints in the tropics.

Manifestations of yaws are similar to those of syphilis. The textbook distinctions are that yaws is not a venereal disease, and that it rarely attacks the viscera or the central nervous system. However, both diseases tend to attack bones and joints. Helfet had the opportunity of studying these diseases for eighteen months in West Africa, and believes that certain features occur probably solely in yaws, thus allowing it to be distinguished from syphilis.

The picture of yaws is more vascular than that of syphilis. It is suggested that it is this vascularity which explains why yaws produces its changes more quickly and that the symptoms are more severe than those of the drier syphilitic gumma. At the same time, this would explain why the disease responds so rapidly when treated with the arsenicals.

Yaws tends to attack joints and tendon sheaths (tendon sheaths, perhaps more often than joints). It is common to find a patient with ganglia involving the dorsal tendons of both wrists or the dorsal tendons of both feet. Sometimes, all four extremities are simultaneously involved.

When treated with arsenicals, the symptoms accompanying these swellings of joints and tendon sheaths rapidly disappear, but the swellings themselves subside very slowly. Helfet excises the ganglia the day after the patient is admitted to the Hospital. He is allowed to return to his Unit when the sutures have been removed. Arsenicals are given the day after the operation, and this treatment is continued by the Unit Medical Officer.

AINHUM

Ainhum is a rare disease seen chiefly among Negroes. It affects any of the digits but most frequently the little toe. A shallow groove is formed on the digitoplantar web, which spreads and encircles the digit. This constricting fibrous ring tightens and in time amputates the toe. In the early stages the digit can be saved by severing the constricting ring. In a case reported by Wright, a corn developed on the dorsum of the foot and a fissure appeared later. There were intermittent attacks of pain in the left fifth toe for five years. The toe was enlarged and tenderness was marked, distally to the furrow. The Wassermann test was 3 plus. Roentgenographs revealed absorption of the shaft and distal extremity of the middle phalanx of the fifth toe. The ungual phalanx showed bone destruction in the shaft and base, the base was disjointed and the cartilaginous surfaces were completely absorbed. There was thickening of the anterior surfaces of the cortex of both tibiæ and narrowing of the medullary canal. Both fibulæ showed osteoperiosteal changes below the necks. The mid-shafts of the leg bones, radius and ulna showed osteosclerotic changes. Amputation of the toe through the line of the furrow resulted in prompt healing and cure. Pain is the most characteristic symptom, and if severe, early amputation is indicated, otherwise a complete line of absorption through the bone should be awaited. The furrow encircling the toe and the characteristic absorptive bone changes are characteristic.

Hook-worm infection is picked up very commonly in the South by persons who walk barefoot.*

TETANUS

Tetanus may result from any deep laceration or puncture of the skin about the foot and ankle or any other part of the body, provided the tetanus bacillus has been introduced into the wound. Such infections are more prone to occur in street injuries or in and around stables and farms, or wherever animal excreta are present. They are also prone to occur in various industrial operations, and in Fourth of July injuries. The usual type of injury results from stepping on a rusty

* *For a discussion of foot and mouth disease the reader is referred to the report of the Ministry of Agriculture and Fisheries published by His Majesty's Stationery Office* 1929

nail which produces a small puncture wound in the sole of the foot which does not necessarily bleed. Compound fractures are very frequently sites of entrance. However, it must be remembered that even though no wound is demonstrable, the person may develop tetanus. The usual incubation period following an injury of the foot or leg is four to seven days. The organisms are usually introduced into the wound as spores. The incidence of the disease in the United States in civil life has been estimated to be 1 case in 1400 wounds.

The Bacillus tetanus is an anaërobic organism, and grows well in association with other organisms, especially with aërobes which use up available oxygen. An exotoxin is produced by the bacteria and attacks nervous tissue which it reaches by way of the nerves, the lymphatics or through the blood stream. It is said that 0.2 mg. of tetanus toxin is fatal for man. This toxin has an affinity for the central nervous system and travels along the axis-cylinders of the nerves. It usually affects the motor nerves but it may also involve the sensory nerves. The toxin is absorbed from the blood by motor end plates.

The pathological changes in tetanus are those of a febrile disease with swelling of the parenchymatous organs.

It is important to recognize the very early symptoms of restlessness, irritability, and a slight rigidity of the neck. The jaw becomes tight and there is some difficulty in mastication. Young children may have generalized convulsions. If definite active symptoms appear, noise, jarring or stimulation of any sort may precipitate muscular spasms. The neck becomes rigid; there is trismus of the jaw and rigidity of the lumbar and abdominal muscles. There may be painful convulsions with constriction of the chest and rigidity and locking of the jaw. Opisthotonos is common "Risus sardonicus" is typical and is due to spasm of the facial muscles. Hyperesthesia may be present. The temperature is usually between 100 and 102°F. and is sometimes higher in children.

The course is rapid, with death from asphyxiation usually occurring in three to four days. Death may be due to spasms of the muscles of respiration. It is sometimes due to circulatory failure, and occasionally to bronchial pneumonia. The patient remains clear mentally. If the case responds to treatment the muscles of the jaw slowly relax with daily increasing ability to open the mouth wider.

The prognosis is much worse in children than adults. The mortality is over 67 per cent. Every day following the tenth day of infection that the patient survives improves his chance of recovery. The longer the incubation period the better the prognosis. The earlier that complete trismus sets in the worse the prognosis. If the jaw locks completely in twenty-four hours, the prognosis is very bad.

Prophylactic measures are the most important factor in treatment;

1,500 units of tetanus antitoxin is the standard prophylactic dose If there is no history of serum having been given before, this amount may be given fairly safely without desensitization In lacerated wounds more should be given The wounds should be well cleansed and never cauterized because necrotic tissue favors the growth of the tetanus organism The dose may be repeated in ten days Some workers have had some success with active immunization with tetanus toxoid Two injections two months apart, each 1 cc of tetanus toxoid, are given Persons frequently exposed to the dangers of tetanus, such as those engaged in military, agricultural and mechanical occupations, may be given lasting immunity against tetanus Active specific therapy consists of tetanus antitoxin in large enough doses After testing for sensitivity, one may give 20,000 units intramuscularly, another 20,000 units intraspinally, and perhaps another dose, very cautiously, intravenously One may also inject 5,000 units around the wound Some clinicians believe there is little value in antitoxin administration once active symptoms set in Nevertheless the patient deserves the benefit of the doubt in every case, but dosage need not be limited to 60,000 units In some cases 100,000 or 200,000 units and even up to 300,000 units have been used

Coudy combines injections of tetanus antitoxin with intravenous injections of methenamine, claiming that this renders the serum less dangerous This is based on the theory that methenamine renders the barrier opposed by the meninges to the hemolysins, permeable His method for prophylactic treatment is to inject intravenously 20 cc of antitetanus serum followed two hours later by intravenous injection of from 0 5 to 1 gram of methenamine, followed after one-half hour by another injection of serum One or two further injections are given subsequently, each preceded by an injection of methenamine

Symptomatic treatment consists of sedation and avoidance of extraneous stimuli Sedatives such as chloral hydrate, luminal, bromides, amytal (especially intravenously), morphine, avertin, and even ether during convulsions, are given

Local treatment of the wound should not be neglected Many advise oxidation with peroxide, or Dakin's solution After careful débridement it is essential to keep the wound open

A case of tetanus coming under my observation was that of a man with a compound comminuted fracture of the lower end of the tibia and fibula involving the ankle joint The lower end of the tibia had been contaminated by dirt Tetanus developed during the five weeks which preceded my first examination Although amputation seemed inevitable, operation consisted of débridement, resection of 2 inches of the tibia, and esquillectomy After the operation, 100,000 units of antitetanus serum were administered by spinal, intravenous, and intramuscular injections, and avertin was given by rectum Bronchial

nail which produces a small puncture wound in the sole of the foot which does not necessarily bleed. Compound fractures are very frequently sites of entrance. However, it must be remembered that even though no wound is demonstrable, the person may develop tetanus. The usual incubation period following an injury of the foot or leg is four to seven days. The organisms are usually introduced into the wound as spores. The incidence of the disease in the United States in civil life has been estimated to be 1 case in 1400 wounds.

The Bacillus tetanus is an anaërobic organism, and grows well in association with other organisms, especially with aërobes which use up available oxygen. An exotoxin is produced by the bacteria and attacks nervous tissue which it reaches by way of the nerves, the lymphatics or through the blood stream. It is said that 0.2 mg. of tetanus toxin is fatal for man. This toxin has an affinity for the central nervous system and travels along the axis-cylinders of the nerves. It usually affects the motor nerves but it may also involve the sensory nerves. The toxin is absorbed from the blood by motor end plates.

The pathological changes in tetanus are those of a febrile disease with swelling of the parenchymatous organs.

It is important to recognize the very early symptoms of restlessness, irritability, and a slight rigidity of the neck. The jaw becomes tight and there is some difficulty in mastication. Young children may have generalized convulsions. If definite active symptoms appear, noise, jarring or stimulation of any sort may precipitate muscular spasms. The neck becomes rigid; there is trismus of the jaw and rigidity of the lumbar and abdominal muscles. There may be painful convulsions with constriction of the chest and rigidity and locking of the jaw. Opisthotonos is common. "Risus sardonicus" is typical and is due to spasm of the facial muscles. Hyperesthesia may be present. The temperature is usually between 100 and 102°F. and is sometimes higher in children.

The course is rapid, with death from asphyxiation usually occurring in three to four days. Death may be due to spasms of the muscles of respiration. It is sometimes due to circulatory failure, and occasionally to bronchial pneumonia. The patient remains clear mentally. If the case responds to treatment the muscles of the jaw slowly relax with daily increasing ability to open the mouth wider.

The prognosis is much worse in children than adults. The mortality is over 67 per cent. Every day following the tenth day of infection that the patient survives improves his chance of recovery. The longer the incubation period the better the prognosis. The earlier that complete trismus sets in the worse the prognosis. If the jaw locks completely in twenty-four hours, the prognosis is very bad.

Prophylactic measures are the most important factor in treatment;

1,500 units of tetanus antitoxin is the standard prophylactic dose If there is no history of serum having been given before, this amount may be given fairly safely without desensitization In lacerated wounds more should be given The wounds should be well cleansed and never cauterized because necrotic tissue favors the growth of the tetanus organism The dose may be repeated in ten days Some workers have had some success with active immunization with tetanus toxoid Two injections two months apart, each 1 cc of tetanus toxoid, are given Persons frequently exposed to the dangers of tetanus, such as those engaged in military, agricultural and mechanical occupations, may be given lasting immunity against tetanus Active specific therapy consists of tetanus antitoxin in large enough doses After testing for sensitivity, one may give 20,000 units intramuscularly, another 20,000 units intraspinally, and perhaps another dose, very cautiously, intravenously One may also inject 5,000 units around the wound Some clinicians believe there is little value in antitoxin administration once active symptoms set in Nevertheless the patient deserves the benefit of the doubt in every case, but dosage need not be limited to 60,000 units In some cases 100,000 or 200,000 units and even up to 300,000 units have been used

Coudy combines injections of tetanus antitoxin with intravenous injections of methenamine, claiming that this renders the serum less dangerous This is based on the theory that methenamine renders the barrier opposed by the meninges to the hemolysins, permeable His method for prophylactic treatment is to inject intravenously 20 cc of antitetanus serum followed two hours later by intravenous injection of from 0 5 to 1 gram of methenamine, followed after one-half hour by another injection of serum One or two further injections are given subsequently, each preceded by an injection of methenamine

Symptomatic treatment consists of sedation and avoidance of extraneous stimuli Sedatives such as chloral hydrate, luminal, bromides, amytal (especially intravenously), morphine, avertin, and even ether during convulsions, are given

Local treatment of the wound should not be neglected Many advise oxidation with peroxide, or Dakin's solution After careful débridement it is essential to keep the wound open

A case of tetanus coming under my observation was that of a man with a compound comminuted fracture of the lower end of the tibia and fibula involving the ankle joint The lower end of the tibia had been contaminated by dirt Tetanus developed during the five weeks which preceded my first examination Although amputation seemed inevitable, operation consisted of débridement, resection of 2 inches of the tibia, and esquillectomy After the operation, 100,000 units of antitetanus serum were administered by spinal, intravenous, and intramuscular injections, and avertin was given by rectum Bronchial

pneumonia was followed by delirium tremens, but complete recovery ensued and very good function was obtained.

TETANUS IN MILITARY PRACTICE

The administration of tetanus antitoxin for the passive protection of wounded soldiers reduced the incidence of tetanus during the period of World War I, from 9 per 1000 in 1914 to less than 1 per 1000 in 1918. This reduced incidence was accompanied by a lengthened incubation period of from 11.8 to 48 days and a lowered case fatality rate of 22.6 per cent in the inoculated and 53.3 per cent among the uninoculated in a series of cases treated in England, and an increase of "local" tetanus from 1.1 to 23.4 per cent.

Powder and bullet wounds, shrapnel wounds, crushing wounds and other injuries can be the portal of entry for the tetanus spores, especially if the wounded soldier lies on the field for some time after injury. Any wound contaminated by soil, manure or débris is a fertile potential source of infection by tetanus.

Tetanus Toxoid.—The war *Primer on Wound Infection*, published in 1940 by British medical authorities, contains a section by Col. L. E. H. Whitby in which the rules now in use for active immunization are laid down. During World War II, tetanus toxoid was used by the British Army and the Royal Air Force. Two doses of 1 cc. of tetanus toxoid were given with a six weeks' interval between. The reaction was slight and the resulting immunity was sufficient to protect the individual for at least two years after inoculation.

Since active immunization was not compulsory and as an added precautionary measure, the Royal Army Medical Service recommend that the wounded man should also be given a prophylactic dose of 3,000 units of tetanus antitoxin.

For the uninoculated patient with a severely lacerated wound or one not surgically excised, a further prophylactic dose of 1,000 units should be given weekly for several weeks.

Active immunization with toxoid was compulsory in the French Army. They advocate a further injection of toxoid for the wounded and already vaccinated soldier.

An established case of tetanus should be treated with massive doses of from 100,000 to 150,000 units given intravenously, and intramuscularly and perhaps also intracisternally or intraspinally as well as subcutaneously around the wound. The best form of treatment, however, is prevention, which is accomplished by specific prophylaxis plus early excision of the wound.

A combination of chemotherapy and specific antitoxins is most effective in holding invading organisms in check, thereby allowing the natural body defenses to combat the infection.

CHAPTER XXIII

ARTHRITIS OF THE FOOT AND ANKLE

Gout—Charcot's Joint—Pulmonary Osteo-arthropathy—Hemophilic Arthrosis

Arthritis of the foot and ankle is a common disabling condition. The industrial aspects of the problem are important because the lesion may follow sprains, contusions, concussions, compressions, fractures, and dislocations. Jamming of the joints may occur while the foot is in hyperflexion, extension, inversion or eversion.

Etiology.—The causes of arthritis include infectious, metabolic, traumatic, and miscellaneous factors. I prepared the following table.

Etiological Factors in Arthritis of the Foot and Ankle[1]

- Infection
  - Local
  - Focal
- Trauma
  - Without infection
  - Plus infection
- Toxins
  - Organic
    - Bacterial
    - Chemical
    - Tobacco
    - Drugs
  - Inorganic
    - Alcohol
    - Lead
    - Sugar
- Circulatory disturbances
  - Arteriosclerosis
  - Embolism
  - Hemorrhage
- Nutritional disturbances
- Mechanical strain
  - Knock knees
  - Bow-legs
  - Flat feet
  - Weak musculature—poor posture
  - Weak ligamentous support
  - Loose bodies in joints
- Endocrine disturbances, especially thyroid and gonads
- Nervous system disturbances
  - Central nervous system
    - Charcot's disease
    - Syringomyelia
    - Cord tumors
    - Peripheral nerve lesions
    - Brain tumor
    - Encephalitis
  - Sympathetic nervous system
- Allergic factors
  - Bacterial
    - Living
    - Dead
  - Chemical
    - Food
    - Plants
    - Animals
  - Physical
    - Heat
    - Cold
    - Moisture
- Climatic conditions
- Congenital defects
  - Bones of extremities
  - Spine
- Neoplasms

[1] Lewin, P.: Jour. Am. Dent. Assn., Feb., 1932.

Injuries and infections are often superimposed upon a postural imbalance. Exposures to extremes of cold and dampness are factors. Arthritis is frequently due to gonococcus infection or trauma from an old fracture or dislocation. Gravity and muscle spasm come into play, the stronger calf group of muscles gradually pulling the foot into plantar flexion. The ankle proper, the tarsal, metatarsal, and interphalangeal joints may be involved. Arthritis of the big toe joint may be serious because the pain or stiffness prevents completion of the step. Subastragalar arthritis most commonly follows fracture of the os calcis or astragalus.

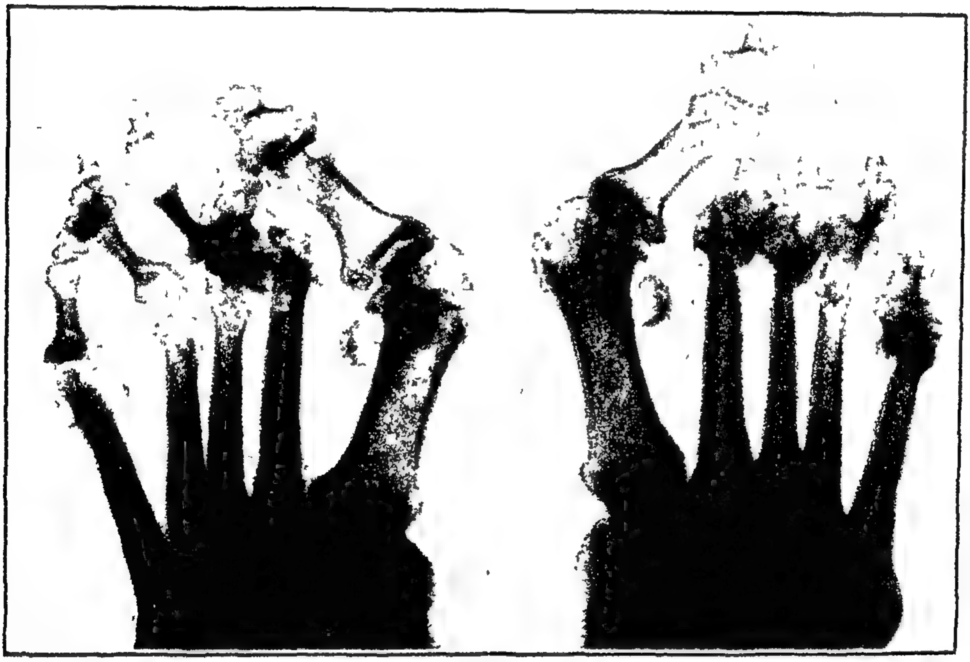


FIG. 265.—Arthritis deformans of feet. Note hallux valgus—other deformities, dislocations. Note radiolucent areas in big toe bones indicative of gout.

Trauma may be acute or continued, mild or severe. One may consider trauma as the only factor, as the precipitating factor and as one which exaggerates a preëxisting condition.

Arthralgia means pain in a joint. There are more foot arthralgias than arthritides. Exposure is an important factor. It may be: mild and continued; moderate and continued; or severe and instantaneous.

Fox-hole arthritis. During World War II the term "fox-hole arthritis" came into use among some military surgeons.

In the foot and ankle, traumatic arthritis is more common than the rheumatoid type. The lesion is most common in the big toe joint with the subastragalar and ankle joints next in frequency.

Infectious arthritis of the foot and ankle is most likely to affect the ankle joint or the big toe joint.

Metabolic arthritis is prone to localize in the foot as gout, a non-purine metabolic disturbance, obesity or diabetes

One must keep in mind the neuritis that occurs in diabetics If Hench is correct one should be careful in prescribing vitamin B_1 because of the likelihood of precipitating an attack of gout

Pathology—Classification —Most writers accept the classification of Nichols and Richardson, considered under the two main headings of proliferative and degenerative arthritis Synonymous with the term "proliferative" are atrophic and infectious, "degenerative" is synonymous with hypertrophic or osteo-arthritic

Degenerative changes occur most commonly in the central portion of the cartilage of the bone, the proliferative changes appear at the margins where the circulation is better

Symptoms —The chief symptoms of arthritis are pain, stiffness, swelling, crepitus, limitation of motion, atrophy and deformity Stiffness is most commonly complained of on resumption of activity after a period of rest (post-inertial dyskinesia) Swelling is most commonly due to synovitis Crepitus, or creaking of the joint, may be palpable or audible, and fine or coarse Limitation of movement is due to pain, stiffness, or swelling

Fatigue is complained of by most patients with arthritis, especially of the infectious type

Deformities include flat-foot, pes cavus and claw-toes with contracture of the extensor tendons, many of which are accompanied by dorsal dislocation at the metatarsophalangeal joints

The roentgenogram reveals atrophic or hypertrophic changes Atrophic findings are indicated by rarefaction or decalcification of bone Hypertrophic bone changes are shown by exostoses or osteophytes which occur so commonly, especially in osteo-arthritis of the big toe joint

Diagnosis —The clinical diagnosis should be made before the roentgenogram shows pathological changes

Prognosis —The factors in the prognosis include age, heredity, general health, duration of the condition, evidence of activity of the disease and the amount of atrophy present The younger the patient, the worse the prognosis If the condition is hereditary, the outlook in unfavorable The greater the atrophy, the worse the prognosis

Treatment —Treatment includes rest, local applications, splinting, traction, physical therapy, weight reduction, injection, synovectomy, arthroplasty, and arthrodesis

The treatment may be divided into prophylactic, remedial and curative Under curative may be mentioned (*a*) treatment of the disease, (*b*) treatment of the patient, and (*c*) treatment of the etiologic factors

The patient is interested in the discomfort, disability and deformity associated with the condition

Under remedial treatment are included local, focal and general measures. Focal treatment includes treatment of various foci such as occur in teeth, sinuses, tonsils, respiratory system, intestines, pelvis, gall bladder, appendix and skin. General treatment involves building up the resistance of the patient and maintaining his morale.

There is no diet for arthritis but there is an optimal diet for every arthritic person. There are two main schools, one group believing that carbohydrates must be cut down or eliminated from the diet; the other that the animal proteins, such as meat, fish and eggs, are harmful. Each person should be put in the condition of optimal nutrition. In the arthritic person who has lost weight a diet containing large amounts of protein is indicated. The arthritic person needs ammunition to fight the disease; this ammunition is supplied by his food and should contain animal protein. Obesity must be corrected. The overweight person who has been eating too much most of his life and who has hypertrophic arthritis would do well to cut down to a considerable degree on meat, fish, eggs, sweets and other carbohydrates.

Drugs may be given by mouth or by rectum, hypodermically or intravenously to relieve pain.

There is no specific medicine for arthritis. The salicylate group has some foundation for its value because it has been proved that it increases capillary blood flow.

The treatment of constipation is important. In selected cases colonic irrigations undoubtedly are valuable. In menopausal arthritis or arthralgia the gynecologist may offer valuable assistance. Theelin in oil and other gonad preparations are often highly beneficial.

Vaccine Therapy.—Vaccines may be non-specific or stock vaccines, specific or autogenous, which include those taken from foci of infection and regional lymph nodes. In vaccine treatment, one is desensitizing and not immunizing the patient, therefore, small doses are advisable. One should maintain the smallest dose that keeps the patient feeling well.

Local Treatment of Painful Feet and Ankles Due to Arthritis.—The routine treatment consists of the application of an anodyne lotion and fomentations and elevation of the feet and legs. This is continued from 9 A.M. until 9 P.M., except for daily physical therapy, viz., massage, heat, inductotherm, whirlpool and hot paraffin dips. From 9 P.M. until 9 A.M. an anodyne ointment is applied and warm dry flannel dressings are used.

My modification of Porter's lotion is as follows:

℞—Tinct. opii	30
Liq. plumbi. subacet. dil.	40
Phenolis, 0.5 per cent	50
Ext. hamamelidis	60

M. et ft. lotio.
Sig.—Externally as directed. "Shake" printed on label.

The chief indications for its use are joints that are painful and limited in movement The technic of application is as follows

COMPARTMENT I
1 Apply 4 layers of gauze over the entire foot and ankle
2 Saturate the gauze with well shaken lotion
3 Apply oiled muslin, oiled silk, or rubber sheeting
COMPARTMENT II
4 Apply flannel or wool wrung out of hot water
5 Apply oiled muslin, oiled silk, or rubber sheeting
6 Add hot water bottles
COMPARTMENT III
7 Cover all with Turkish towels
8 Elevate the foot and leg
9 Refill the hot water bottles every two or three hours
REMARKS
10 Add lotion three times daily from 9 A M until 9 P M
11 From 9 P M until 9 A M use an anodyne ointment plus dry heat and woolen or flannel coverings A large woolen golf stocking is excellent

After a variable period during which pain disappears a plaster cast is applied and crutches are prescribed

Physical therapy includes thermotherapy, massage, hydrotherapy, contrast baths, hot paraffin dips, mineral baths, mud baths, passive exercises, active exercises, posture work, mechanotherapy, manipulation, passive congestion, diathermy, inductotherm, autocondensation and negative galvanism, colon therapy, heliotherapy, climatotherapy and marinotherapy Hemotherapy includes blood transfusion, autoserotherapy and autohemotherapy Roentgenotherapy and radiotherapy are of definite value in relieving pain

The non-operative orthopædic treatment of arthritis includes rest in bed, counterirritation, heat, casts, splints, braces, and forcible manipulations The operative treatment may be divided into bloodless and open operations The chief illustration of bloodless operation is forcible manipulation under anesthesia Open operations include osteotomy, tenotomy, capsulotomy, synovectomy, cheilectomy, arthroplasty and sympathetic nerve operations

Arthritis of the Ankle Joint —Arthritis of the ankle is common during the course of, or following, an acute infection The symptoms are pain, swelling, crepitus, limitation of motion, tenderness, and sensitiveness The treatment includes rest, the application of an anodyne lotion and fomentations, elevation, physical therapy, and support such as a plaster cast, adhesive strapping, an elastic anklet, or a brace A proper shoe modified to correct static imbalance with resilient supports within, should be prepared before weight-bearing is permitted Crutches are helpful for a period

FIG. 266.—Arthritis involving astragaloscaphoid joint. (Note the fusion of calcaneus and cuboid All mid-tarsal joints are fused.)

FIG. 267.—Fracture of astragalus with traumatic arthritis of ankle and subastragalar joints.

The ankle is a common site for the monarticular arthritis of gonorrhea Excellent results are obtained with artificial fever therapy using the Kettering hypertherm unit, sulfanilamide and penicillin

FIG —268 —Extreme deformity due to arthritis

Arthritis of the Subastragalar Joint —The chief cause of arthritis of the subastragalar joint is a fracture of the astragalus or os calcis The local signs and symptoms are similar to those of arthritis of the ankle Eversion and inversion cause pain Walking over cobble stones is usually painful A twist or sprain usually causes severe pain The entire ankle and posterior part of the foot are painful The diagnosis may be confirmed by roentgen-ray Treatment is similar to that of arthritis of the ankle joint

"Arthritis of the Heel"—Spurs on the calcaneus are usually classed as arthritis, although technically they should not be The usual location is the region of the attachment of the plantar fascia (See Chapter XI) Periostitis of the os calcis may be due to causes similar to those producing arthritis Bursitis may be present

Arthritis of the Tarsal Joints.—Arthritis of the tarsal joints may occur from a local or focal infection. Toxic arthritis is common. Trauma is an important cause.

The treatment includes local applications of an anodyne lotion, fomentations, elevation, and rest. Physical therapy and some support such as plaster, adhesive or an elastic anklet are advisable. The shoes should be modified to correct any static imbalance.

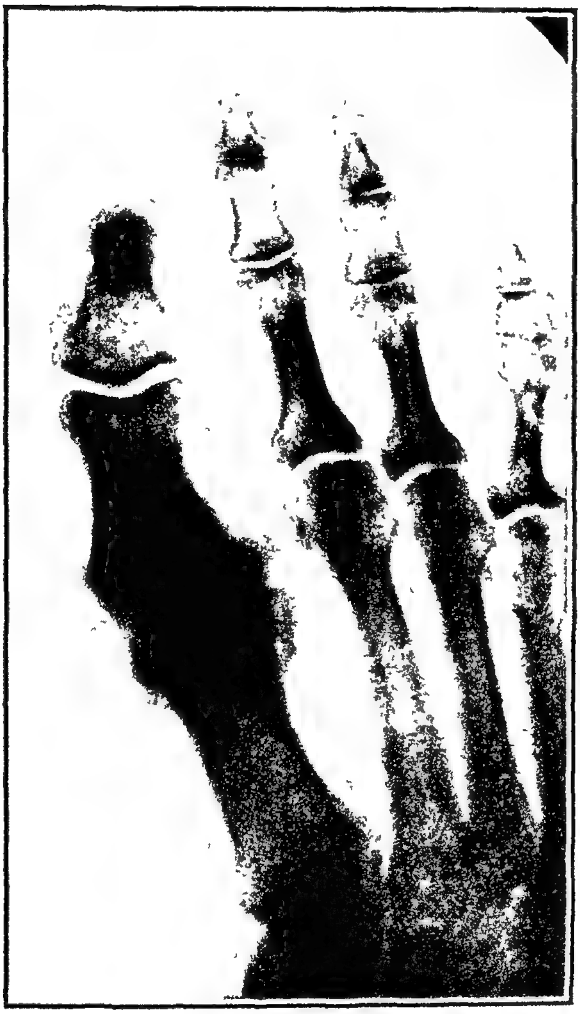


Fig. 269.—Septic arthritis of the first metatarso-phalangeal joint.

The treatment is that of arthritis in general. After the patient is allowed out of bed it is important that he wear proper shoes, that is, shoes with modified heels, metatarsal crescents, and felt pads to support the arches.

Arthritis of the Toe Joints.—Arthritis occurs most commonly in the great toe joint in the form of arthritic, periarthritic, and gouty condi-

tions In cases of severe deformities of the toes, plastic operations are frequently required Hoffmann's operation is illustrated in Figure 124

Arthritis of the metatarsophalangeal joint of the great toe joint produces hypertrophic outgrowths corresponding with Heberden's nodes in the fingers Repeated minimal trauma from the shoe or severe single blows are common causes

Fig 270 —Hallux rigidus due to traumatic arthritis of the great toe

(Hallux rigidus is discussed in Chapter IX)

Synovitis can attack any joint It may be due to reduplication of synovia, infection or trauma Capsulitis, fasciitis and fibrositis are frequently encountered

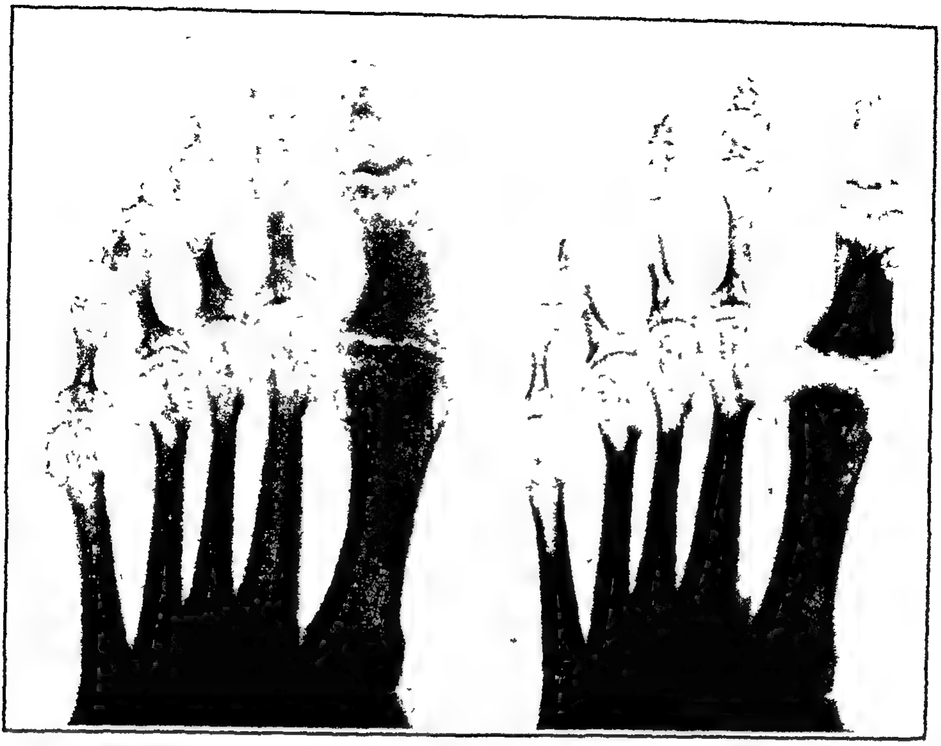


FIG. 271.—Arthritis of the first metatarsophalangeal joint with ankylosis, before and after arthroplastic operation.

GOUT

Gout is a generalized disturbance of purin metabolism manifested by the deposition of uric acid products in or about the joints, causing them to become painful, swollen, red, and tender. In addition to the acute and chronic phases, I recognize a type which I call "imminent gout."

In one of the large eastern hospitals that is noted for its work in arthritis, it was estimated that in one year there was 1 case of gout for each 400 patients admitted.

Etiology.—Gout is a disease of unknown etiology characterized by (1) arthralgia, which is at first acute and recurrent, each attack being followed by complete symptomatic remission, but which later tends to become chronic; (2) supposed abnormality in the renal excretion of uric acid, an end-product of purine metabolism; (3) hyperuricemia, which is usually transient at first but later generally becomes chronic; (4) eventual deposits of sodium urate crystals in articular, periarticular and subcutaneous tissues, sometimes also in kidneys and urinary tract; (5) frequent terminal vascular lesions in the kidneys, sometimes also in the heart and brain.

Recent opinions are that gout results from (1) some endocrine deficiency, (2) abnormal renal insensitivity to urates, (3) selective renal

insufficiency for urates alone, (4) a "storm in the vegetative nervous system," a functional disturbance involving the renal or the thoracic sympathetic nerves or (5) an allergic reaction to proteins, not necessarily to exogenous proteins derived from foods rich in purine, but also to proteins from certain non-purine foods as well as to endogenous proteins, tissue substances formed after injuries, vasomotor disturbances or operations. Gout and gouty arthritis are not synonymous, the latter is merely the dominant symptom of gout.

Gout is primarily a disease of males over the age of thirty-five. Heredity is a factor in the transmission of the diathesis. Overeating, especially of animal and highly seasoned foods, without sufficient activity, is a definite predisposing cause. Many gouty persons are particularly fond of such foods as liver, brain, kidneys, and sweetbreads which are rich in purine bodies. When uric acid-forming foods are ingested in large quantities the body may be unable to excrete the uric acid at a sufficiently rapid rate. Many attacks of gout can be traced to dietary indiscretions on holidays or other special occasions, or to trauma, exposure, and dietary excesses while on vacation trips.

The overuse of alcohol is an important factor. Fermented liquors (wine, beer, ale, and malt liquors) are much more liable to produce gout than distilled liquors (whiskey, gin, brandy, and cordials). Heavy beer drinkers often suffer from gout. The overuse of tobacco may increase a tendency toward gout. Hench warns against vitamin B_1.

Overwork, exposure to cold, mental strain, worry, a sudden mental shock or a surgical operation may bring on an attack. Trivial or unnoticed trauma may provoke, within a few hours, an attack, the severity of which is entirely out of proportion to the trauma. Attacks may be brought on by trauma to the feet such as occur during athletics, in driving an automobile, dancing, or walking a long distance.

An acute attack of gout may be precipitated during the course of treatment of gout. This phenomenon is seen in the treatment of other diseases for example, by liver therapy for pernicious anemia, by a ketogenic diet for bacilluria, or by the administration of salyrgan, mercurin, or other diuretics for edema, by ergotamine tartrate for migraine, and by insulin for diabetes. Prolonged exposure to cold or sudden changes of body temperature may precipitate an attack.

In an article on "Exposition Feet," Clendening quotes Hench as warning that as people walk around the world's fairs they are guilty of dietary indiscretions, excessive walking and standing, and excessive drinking, which *predispose to gout*.

Pathology.—The chief changes are in the articular tissues. The condition affects most commonly the big toe joint and next most commonly the ankles, knees, and the small joints of the hands and wrists. A deposition of urates may cause necrosis

The ligaments and fibro-cartilage may become involved and become infiltrated with biurate deposits, forming whitish nodules called "tophi." These are commonly found in the ear.

Pattern of Gout.—Hench outlined the pattern of gouty arthritis. *The larval stage* of gout is that period of the disease prior to the first attack. This stage is usually symptomless; sometimes it is accompanied by transient hyperuricemia of varying intensity. *The first attack* of gouty arthritis sometimes occurs in a young person but usually affects men, over thirty-five or forty years of age, appearing suddenly, lasting from three to ten days and disappearing completely. In 60 per cent of cases it affects the great toe, but it may affect an instep, ankle, knee or other peripheral joint. *A second attack* usually occurs after a year or so. Sooner or later the tempo and severity of the disease generally increase. Early attacks are generally monarticular and afebrile; later attacks are often polyarticular and may be febrile.

Thus the pattern of classic gouty arthritis can be divided into two great stages comprising four phases. Stage I is that of acute recurrent gouty arthritis. Stage II is that of chronic gouty arthritis. The first two phases are in Stage I, and are described above. The third and fourth phases are in Stage II. The third phase is characterized by acute attacks and incomplete remissions. Subcutaneous tophi on the ears, elbows and around joints are almost always present and may be multiple and ulcerating, and osseous tophi of the hands or feet are commonly present. In the fourth phase, a relatively painless chronic gouty arthritis occurs; hyperuricemia and multiple tophi are almost always present.

Symptoms.—The acute type of gout is ushered in by a severe attack of pain, usually in the big toe joint, during the night. In some cases there are prodromal symptoms for several days. The joint swells, the surrounding skin becomes red, and the area tender. There may be a rise in temperature.

The uric acid content of the blood is increased. Roentgenograms reveal radiolucent areas in the bone due to the deposits of biurates. The urine is usually scanty, highly colored, and acid. The attack may last for several days, and as a rule is more severe during the night than during the day. In chronic cases of gout the articular symptoms persist for a longer time, and ultimately many joints are affected. When the chronic condition persists for years, the joints often become deformed. In Hench's series of 100 cases, true proved tophi were found in 41. While tophi may be found in many locations, they have a peculiar affinity for the ears. Tophi of the heels resembling pyogenic lesions are extremely uncommon. Christopher and Monroe reported the case of a blacksmith who had ulcerated tophi of both heels which

had been operated upon five times under the mistaken diagnosis of pyogenic ulcerations

Diagnosis —The diagnosis is based on the history of sudden attacks of joint pains, hyperuricacidemia, and translucent areas in the roentgenogram

Gout should be considered the basis of joint pain if the patient has an inherited tendency to that condition, gives a history of indulgence in animal foods or alcoholic drinks, and has had repeated attacks of pain with intervening periods of health, and absence of permanent joint damage Gout can be assumed on the basis of a typical history, a characteristic appearance of the involved joints, and an abnormal amount of uric acid in the blood It can be diagnosed with certainty when an uratic tophus is found

Kirklin believes that a presumptive diagnosis can be made on the history of repeated acute attacks with complete remission in spite of the absence of tophi, characteristic punched-out areas in the roentgenogram, and a high content of uric acid in the blood

Ferguson finds that in infectious arthritis the lesion is in the center of the soft-tissue shadow, whereas in gout, it is eccentric

A high purine diet is the provocative test The therapeutic test of remission on proper diet and cinchophen is of diagnostic value

A reading of more than 3 mg of uric acid per 100 cc of blood, with the patient on a purine-free diet, is suggestive but not diagnostic of gout

Repeated attacks of bursitis, especially at the elbow, should make one suspicious of gout

The clinical course of gout is one of repeated attacks with complete remissions Supplementary evidence may be obtained from a history of involvement of the great toe and bursitis and from a study of the patient's habits with regard to foods and alcohol, his hereditary background, and provocative purine-tolerance tests These tests are made by intravenous injection or ingestion A purine substance, generally lithium urate, may be given intravenously and studies then made of its clinical effect on the joints and the amount and rate of excretion of the injected urate

Another method of testing the purine tolerance is to direct the patient to ingest a diet containing about $\frac{2}{5}$ gm of purine during each twenty-four hours and determine the uric acid output It has been stated that a diet high in fats and low in carbohydrates makes gout worse

In view of the fact that gouty arthritis is the most common form of acute arthritis affecting men over forty years of age, gout should be thought of immediately when attacks of arthritis develop in a man of this age, if other causes can be excluded

Darnall and Hench offer the maxim: "Suspect gout in cases of post-operative arthritis, especially in males."

True gout is not very often seen at present, but there is a definite condition of arthritis[1] or periarthritis in the region of the big toe joint that is either caused or aggravated by disturbances of metabolism, especially the metabolism of purines. Characteristic symptoms are pain, swelling, redness, tenderness of the toe, and limp. Many attacks occur between 2 and 4 o'clock in the morning, especially a few hours after a minor injury.

A study of the symptoms, physical signs, and roentgen-ray findings is necessary to differentiate the condition from osteomyelitis of the big toe. Acute osteomyelitis usually causes the patient to seek treatment during the first attack, when the roentgenograms are still negative.

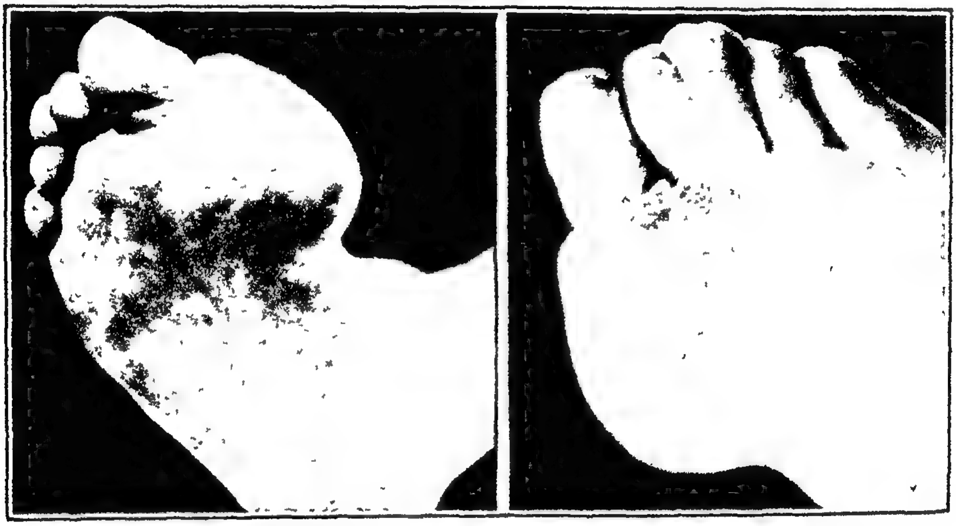


FIG. 272.—Gout affecting the great toe region. (Courtesy of E. W. Ryerson.)

In cases of gout, the probabilities are that there have been several attacks and the roentgenograms will show areas of decreased density in the bone due to deposits of sodium biurate.

It is possible for patients to have a normal uric acid concentration in the blood during an early acute attack. As the disease progresses, hyperuricacidemia becomes more obvious and more chronic.

The term "imminen[illegible] [illegible] applie[illegible] of person who may not present any sy[illegible] [illegible]st dietary indis-cretion, acquires [illegible] [illegible]son is "on the fence," and sho[illegible]

1. Relatively [illegible] which is out of pr[illegible] tack ma[illegible]

I suggest

3 Acute postoperative arthritis occurring within the first six days after an operation is generally gout

4 The trauma, exposure and the dietary excesses of fishing, hunting, and vacation trips are common incitants

5 An acute attack of gouty arthritis frequently may be precipitated in the course of treatment of gout-susceptible patients for coincident disease, namely, by liver therapy for pernicious anemia, by a ketogenic diet for bacilluria, by salyrgan or other diuretics given for dropsy, by ergotamine tartrate (gynergen) administered for migraine, or rarely by insulin for diabetes

6 A gouty patient with coincident polycythemia or leukemia is particularly prone to marked activity of his gout

7 About 98 per cent of patients who have gout are men

8 Gouty arthritis is the most common form of acute arthritis to affect men aged more than forty years, and gout should be thought of first when attacks of arthritis appear in a man of this age, if gonorrhea and acute trauma have been excluded

9 The incidence of attacks of gouty arthritis is greatest in Spring and Fall although they may occur in any month

10 While an attack may come on at any time during the day or night, it is especially prone to occur between 2 and 7 A M

11 The speed of onset and development of an attack is usually rapid The maximal pain and swelling are usually reached within thirty-six hours of the onset of any attack

12 The pain of gout may be moderate or severe

13 From one to two or more joints are involved Podagra (pain in big toe joint) is present in approximately 60 per cent of attacks

14 When the great toes are involved the maximal tenderness is generally on the mesial aspect of the metatarsophangeal joint

15 The affected foot is not cold and bluish-white (as in atrophic arthritis) but warm and bluish-red, the skin is often shiny, edema and later desquamation of skin are commonly noted

16 Attacks are usually of relatively short duration varying from seven to twenty-one days

17 The tendency to full restitution of articular function is notable and for a long time the remissions are complete

18 Olecranon bursitis is common in gout

19 Attacks of renal colic or nephritis not uncommonly develop in cases of gout

20 Prodromes of a gouty attack may be gastro-intestinal disturbances, irritability, dizziness, and urinary symptoms

21 The response to therapy is practically diagnostic

To these, the author should like to add two points

22 Gout is like asthma of the bones and joints

Darnall and Hench offer the maxim: "Suspect gout in cases of postoperative arthritis, especially in males."

True gout is not very often seen at present, but there is a definite condition of arthritis[1] or periarthritis in the region of the big toe joint that is either caused or aggravated by disturbances of metabolism, especially the metabolism of purines. Characteristic symptoms are pain, swelling, redness, tenderness of the toe, and limp. Many attacks occur between 2 and 4 o'clock in the morning, especially a few hours after a minor injury.

A study of the symptoms, physical signs, and roentgen-ray findings is necessary to differentiate the condition from osteomyelitis of the big toe. Acute osteomyelitis usually causes the patient to seek treatment during the first attack, when the roentgenograms are still negative.

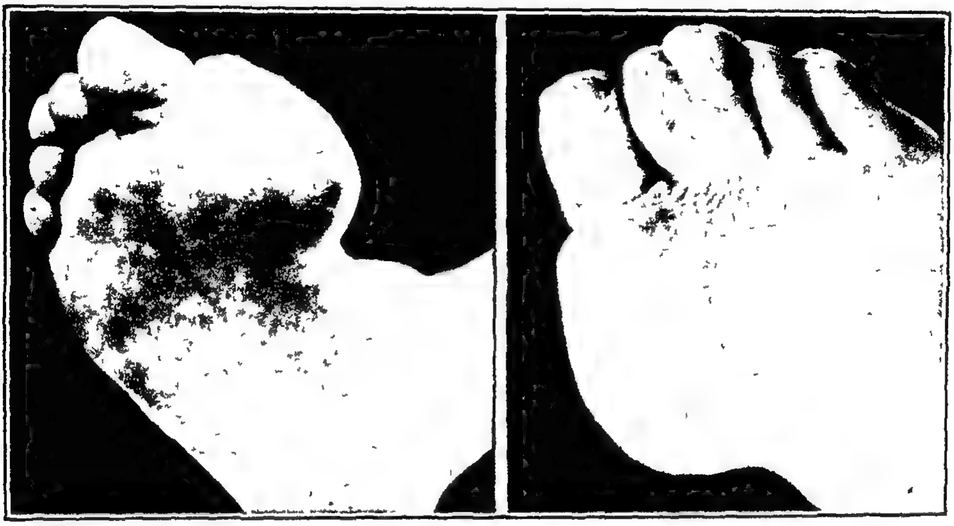


Fig. 272.—Gout affecting the great toe region. (Courtesy of E. W. Ryerson.)

In cases of gout, the probabilities are that there have been several attacks and the roentgenograms will show areas of decreased density in the bone due to deposits of sodium biurate.

It is possible for patients to have a normal uric acid concentration in the blood during an early acute attack. As the disease progresses, hyperuricacidemia becomes more obvious and more chronic.

The term "imminent gout" is applied to the type of person who may not present any symptoms ordinarily, but with the least dietary indiscretion, acquires mild symptoms of gout. Such a person is "on the fence," and should be treated prophylactically.

Hench's "Goutograms"

1 Relatively trivial trauma may provoke an attack, the severity of which is out of proportion to the trauma.

2. An attack may follow dietary indiscretions, especially on holidays.

[1] I suggest the word "podagric" analogous to "arthritic."

3 Acute postoperative arthritis occurring within the first six days after an operation is generally gout

4 The trauma, exposure and the dietary excesses of fishing, hunting, and vacation trips are common incitants

5 An acute attack of gouty arthritis frequently may be precipitated in the course of treatment of gout-susceptible patients for coincident disease, namely, by liver therapy for pernicious anemia, by a ketogenic diet for bacilluria, by salyrgan or other diuretics given for dropsy, by ergotamine tartrate (gynergen) administered for migraine, or rarely by insulin for diabetes

6 A gouty patient with coincident polycythemia or leukemia is particularly prone to marked activity of his gout

7 About 98 per cent of patients who have gout are men

8 Gouty arthritis is the most common form of acute arthritis to affect men aged more than forty years, and gout should be thought of first when attacks of arthritis appear in a man of this age, if gonorrhea and acute trauma have been excluded

9 The incidence of attacks of gouty arthritis is greatest in Spring and Fall although they may occur in any month

10 While an attack may come on at any time during the day or night, it is especially prone to occur between 2 and 7 A M

11 The speed of onset and development of an attack is usually rapid The maximal pain and swelling are usually reached within thirty-six hours of the onset of any attack

12 The pain of gout may be moderate or severe

13 From one to two or more joints are involved Podagra (pain in big toe joint) is present in approximately 60 per cent of attacks

14 When the great toes are involved the maximal tenderness is generally on the mesial aspect of the metatarsophangeal joint

15 The affected foot is not cold and bluish-white (as in atrophic arthritis) but warm and bluish-red, the skin is often shiny, edema and later desquamation of skin are commonly noted

16 Attacks are usually of relatively short duration varying from seven to twenty-one days

17 The tendency to full restitution of articular function is notable and for a long time the remissions are complete

18 Olecranon bursitis is common in gout

19 Attacks of renal colic or nephritis not uncommonly develop in cases of gout

20 Prodromes of a gouty attack may be gastro-intestinal disturbances, irritability, dizziness, and urinary symptoms

21 The response to therapy is practically diagnostic

To these, the author should like to add two points

22 Gout is like asthma of the bones and joints

23. Unaffected females may transmit the predisposition, as in hemophilia.

Treatment.—Prophylaxis.—Children and relatives of gouty patients should live moderately and avoid the provocatives of acute gout.

Treatment of Acute Gouty Arthritis.—Prodromal symptoms of an attack are sometimes manifested by nausea, dyspepsia, polyuria or euphoria or by twinges of pain in a joint. The attack can sometimes be aborted by taking a brisk cathartic and a few doses of colchicine (each dose $\frac{1}{100}$ grain [0.65 mg.] every two or three hours).

During an acute attack, attention must be directed to rest, heat or cold, a cathartic, colchicine, cinchophen, diet and possibly narcotics.

Cathartic.—Magnesium sulfate from $\frac{1}{2}$ to 1 ounce (15 to 30 grams), solution of magnesium citrate from 6 to 12 ounces (180 to 360 cc.) or sodium phosphate from 4 to 8 grams. This type of treatment is empiric but supposedly helpful.

Rest.—Affected parts should be rested completely, preferably in bed, and protected from the weight of bedclothes. Weight-bearing should be avoided until pain and tenderness disappear.

Heat or Cold.—Simple hot water compresses are preferable to dry heat. Sometimes cold compresses give more relief. Lotions such as aconite, belladonna or chloroform are sometimes prescribed.

Colchicine.—Colchicine tablets, each $\frac{1}{120}$ or $\frac{1}{100}$ grain (0.53 or 0.65 mg.), should be given; 2 tablets initially and 1 tablet every two or three hours (in severe cases even during the night) until pain is relieved or some gastro-intestinal disturbance, such as nausea or diarrhea, appears. Colchicine is more consistently effective than the wine or tincture of colchicum (dose from 15 to 30 minims or 1 to 2 cc. every two to four hours), which sometimes deteriorates. Gouty patients should carry a few colchicine tablets for prompt use when necessary.

Narcotics.—Until pain is controlled by colchicine and compresses, a dose or two of codeine (from $\frac{1}{2}$ to 1 grain, or 0.032 to 0.065 gram) or morphine sulfate (from $\frac{1}{6}$ to $\frac{1}{4}$ grain, or 0.01 to 0.016 gram) may be required.

Cinchophen and Substitutes for Cinchophen.—Attacks are better controlled when cinchophen or a substitute for it, is used to supplement other measures, especially if hyperuricemia is present. Cinchophen should be given during attacks thus: $7\frac{1}{2}$ grains (0.5 gram) three or four times daily with the precautions noted later (alkali, carbohydrates, extra fluid).

Some physicians prefer to prescribe one of the following substitutes daily during the attack: neocinchophen from 5 to $7\frac{1}{2}$ grains (0.3 to 0.5 gram) three times a day; sodium salicylate 20 grains (1.3 grams) four times a day or acetylsalicylic acid 20 grains (1.3 grams) three or four times a day.

Diet.—The diet currently approved for acute gouty arthritis is free of purines and low in fats (the latter inhibits urate excretion), rich in carbohydrates, which increase urate excretion, and rich in purine-free proteins (milk, eggs, cheese). This diet minimizes the formation of exogenous urates and fosters elimination of endogenous urates. Its rationale may be questioned when it is realized that many patients during attacks excrete urates normally or even excessively. Future work must determine how necessary purine restrictions are during attacks, but then of all times patients are receptive to instruction in those dietary restrictions which the interval treatment of gout seems to require. Complete abstinence from alcohol is advisable.

During an acute attack a patient with gout should be on a purine-free diet. After the attack is over he should continue on a *purine-low diet four or five days a week and a purine-free diet two or* three days a week. A diet list used in one American clinic where many patients with gout are seen, is as follows:

1	2	3
Foods that contain a large amount of purine	Foods that contain a moderate amount of purine	Foods that contain no purine
	(a)	
Sweetbreads Liver Kidney Squab Calf's tongue	Chicken Mutton Bacon Oysters Herring	Milk Eggs Cheese Caviar Shad roe Nuts
	(b)	
Turkey *Pork* Veal Sausage Beef Goose Anchovies Sardines Trout Pike Perch Codfish Lentils Gravies Meat extractives Meat soups	Salmon *Lobster* Crab Whitefish Asparagus Lima beans Navy beans Kidney beans Kohlrabi Onions Peas Spinach Mushrooms Oatmeal Whole grain cereals—such as cooked whole wheat *and wheat biscuits* Whole-grain bread—such as whole wheat and graham bread	Gelatin *Sugar and sweets* Cocoa[1] Fats of all kinds Fruits of all kinds Cereals (except whole grain) Bread (except whole grain) Vegetable soup (made without meat) Vegetables of all kinds except those listed in Column 2 such as Lentils Spinach Mushrooms Peas *Lima beans* Navy beans Kidney beans Kohlrabi Asparagus Onions

[1] Contains practically no purine as served

It is generally recommended that patients whose gout is moderately active confine their foods largely to those in column 3, eat one selection daily from foods listed in column 2, avoid foods in column 1 *a* entirely, and eat one selection from foods in column 1 *b* on rare occasions only, perhaps once every one or two weeks or less often, depending on the severity of their gout. Moderate amounts of coffee and tea are permissible. All wines and liquors should be avoided. Although they contain no purines or only minute amounts, they adversely affect gouty patients.

Under the described treatment, the attack generally subsides promptly. In cases in which there have been a few prolonged attacks, the injection of small doses of a foreign protein may hasten recovery. As the symptoms subside and the uric acid in the blood definitely recedes, the patient may be permitted to eat foods with a moderate purine content in slowly increased amounts and at gradually shortened intervals.

The internal administration of atophan or colchicum often affords almost instant relief of the symptoms. For an acute attack involving the smaller joints, Frauenthal, who had a very large experience with gout, recommended the application of a sponge electrode saturated with the fluid extract of colchicum and attached to a galvanic current of a strength up to the point of the patient's tolerance of pain, which was reversed every two minutes. Three treatments in thirty-six hours often relieve the pain and reduce the swelling.

The majority of physicians interested in gout in this country regard the intermittent use of cinchophen necessary for the adequate control of the gout in most cases.

It is not certain whether liver damage from cinchophen can ever be completely avoided in the susceptible individual regardless of the method of administration. However, the great majority of persons, including patients with gout, are apparently not susceptible to cinchophen and can take it repeatedly with impunity. Graham's method of administration is as follows: 7½ grains (0.5 Gm.) three times a day for three or four consecutive days each week. When the patient is taking cinchophen he should also take from 1000 to 1500 cc. of fluid daily and enough alkali to alkalinize each specimen of urine voided (*e. g.*, sodium bicarbonate, 2 teaspoonfuls in the morning and 1 or 2 in the evening). Some recommend also that generous amounts of carbohydrate be taken on the days when cinchophen is used.

Early signs of susceptibility to cinchophen are gastro-intestinal upsets (nausea) and urticaria or other skin reactions. With the appearance of these symptoms, which seem to be due to the cinchophen (and not to the alkali), cinchophen should be stopped, probably permanently. Some believe that hives do not afford a permanent contraindication

to cinchophen in the case of gouty patients who cannot control symptoms otherwise and that hepatic susceptibility does not necessarily accompany skin susceptibility They recommend the continued use of cinchophen in smaller doses When the more serious signs of cinchophen toxicity appear (loss of weight, dyspepsia, icterus, pruritus) administration of the drug should, of course, be stopped immediately and appropriate therapy started (intravenous dextrose, high carbohydrate diet, generous fluid intake) The results of such treatment are usually satisfactory, and fatal cases of cinchophen toxicity are becoming fairly rare

There is no established pharmacologic substitute for cinchophen In general, the amounts of salicylates necessary to reproduce the effect of cinchophen on urate excretion are so large that gastro-intestinal irritation and perspiration are induced Colchicine has no effect on urate excretion Recently, Hench and Rutledge and Bedard (Criteria for the Diagnosis of Presumptive Pretophaceous Gout) have noted preliminary clinical observations on the synergistic action of salicylates and amino-acetic acid on urate excretion and have suggested that this combination may prove to be an effective substitute for cinchophen This is supplemental to the physiological observations of Quick

The purpose of giving alkali during cinchophen administration is to prevent urates, which are being excreted in excess, from precipitating as stones or gravel in an acid urine

Massive doses of thiamin chloride used in conjunction with generally accepted routine management for gout appear to reduce the period of disability Callahan and Ingham treated 9 patients with gout, with 4500 to 9000 international units of vitamin B_1 (thiamin chloride) daily, along with analgesics, a purine-free diet, dry heat and balneotherapy Vitamin B_1 therapy in these patients seems to decrease the length of the acute attack of gout and to increase the period of freedom from symptoms In many instances, pain subsides in from twenty-four to seventy-two hours after the injection of a massive dose of thiamin chloride Proper shoes and their modifications both inside and outside can do much for painful feet, but they cannot correct the metabolic disturbance

Interval Treatment of Symptomless Gout and Control of Hyperuricemia —Gout is not cured when the attack is over Gout is a chronic disease for which treatment must be continued indefinitely in an attempt to prevent or postpone return of symptoms Contrary to the belief of a few physicians that no regimen materially alters the "relentless progress of gout," most physicians believe that, by adhering faithfully to the interval treatment, the majority of patients can sharply modify the course of their disease, reduce the number and severity of attacks, prevent or reduce the likelihood of chronic gouty arthritis and avoid

or postpone the late and sometimes fatal renal and cardiovascular complications. The faithful and successful adherence to such a regimen, however, requires, most of all, a high degree of self-discipline on the patient's part.

Prophylaxis.—Prophylaxis should be based upon a proper diet, physical education, and treatment at mineral springs. Prophylactic measures include long walks and regular attendance at the gymnasium.

The diet should be entirely or nearly purine-free. Foods rich in nucleins such as liver, thymus, kidney, brain, pancreas, sardines, herring, shellfish, caviar, fish roe, meat extracts, and bouillons should be prohibited. The ideal diet is composed chiefly of milk, cream, cheese, eggs, fruits, and fresh vegetables.*

All malt liquors, wines, and other alcoholic beverages are contraindicated. Fluids should be taken freely. Foldes advises an antiretentional diet to prevent the accumulation of water in the tissues One should beware of concentrating the blood and urine.

Hench recommends that the gouty person be educated along proper lines of metabolism, hygiene, and physical activity. Regular hours and daily bowel evacuations are essential. Some mineral waters are helpful, particularly those containing alkalies. A person with gout or "imminent gout" must avoid exposure to extremes of temperature and quick changes in body temperature. Limitation of the intake of protein is advisable. The following diet has proved very satisfactory:

May Have

Soups—Cream soups flavored with cauliflower, carrots, corn and celery.
Vegetables—All except peas, beans, lentils, asparagus, onions, radishes, and rhubarb.
Fruits—All fresh, stewed fruits and canned fruits.
Fats—Butter, cream, olive oil, fat bacon.
Cereals—Wheat, corn and rice cereals, macaroni and spaghetti.
Desserts—Simple puddings, tapioca, rice, sago, cornstarch, custard, ices and ice cream.
Eggs—In any form except hard boiled and fried.
Milk and cheese—Large quantities.
Fluids—Milk, lemonade, orangeade, fruit juices, or buttermilk.
Breads—White, graham, rye or corn bread, zwieback, crackers or plain cakes.

Avoid

Nuts, oatmeal, meat soups, apples, tea, coffee, cocoa, and coca cola

Drink Kalak or Gerolsteiner water

In cases of severe local symptoms, but with a normal blood uric acid, gout exhibits a seasonal effect, becoming acute, particularly during the Spring (February-May) and Autumn (August-October). During these months, patients should be particularly careful to avoid the

* *It is only the proteins which are rich in compounds of nitrogen that cause trouble.*

various provocatives of gout, they should adhere to their diets, probably take cinchophen intermittently, and avoid unusual trauma such as excess activity (from golfing, walking or long automobile driving) The amounts of physical and recreational activity to which the patient is accustomed can generally be indulged in with impunity, it is the unaccustomed amounts (often indulged in during vacations) that may provoke an attack

Water retention is considered important by Foldes It must not be attacked by mercurin or salyrgan until an anti-retention diet has been enforced for several days The special water retaining foods are carbohydrates salts and fats

CHARCOT'S JOINT

Neuropathic arthropathies are found in *tabes dorsalis, syringomyelia, compression and destruction of the spinal cord, severance of nerves, pernicious anemia,* and *peripheral neuropathy* In tabes dorsalis, the joints of the lower extremity are usually affected

Charcot's joint is due to neurotrophic and infectious factors Because of the neurotrophic factor, normal trophic impulses fail to reach the joint The infectious factor is a local infective agent or its toxic by-products

King believes that hypertrophic Charcot's disease is a form of osteoarthritis and that the aggravation of the processes is due chiefly to the more frequent traumatisms which are permitted by the anesthesia of the bone and joint structures While a neurogenic background predisposes a joint to arthropathic disintegration, mechanical and traumatic events determine the course of the disease and lead to the breakdown of the articulation

Charcot's joint is painless in most cases, and may develop rapidly, producing joint instability

The lesion has been produced experimentally in animals by section of the posterior (sensory) roots, which inhibits the warning sense of pain in a limb Charcot's joint may be the result of a single trauma such as a fracture into a joint *Its recognition is, therefore, important in the adjustment of claims in industrial cases and in determining employer's liability* Compensation should not be denied the patient with inactive syphilis who develops a Charcot joint which appears immediately following a severe injury, received in the pursuance of his occupation

Pathology —The pathological changes include extensive destruction of articular cartilage and bone The lateral ligaments and capsule undergo stretching and weakening There is bone destruction with loosening of bone plaques Bone proliferation may progress simultaneously with the destruction

Symptoms.—The pupils do not react to light (Argyll-Robertson). Tendon reflexes are occasionally exaggerated at first, but absent later. There may be "lightning" pains, especially in the legs. The Romberg sign consists of instability while standing with the eyes closed. There are motor disturbances, such as an ataxic gait, involuntary movements, and palsies. Gastric crises and disturbances of the visual, auditory, and visceral apparatus may be present.

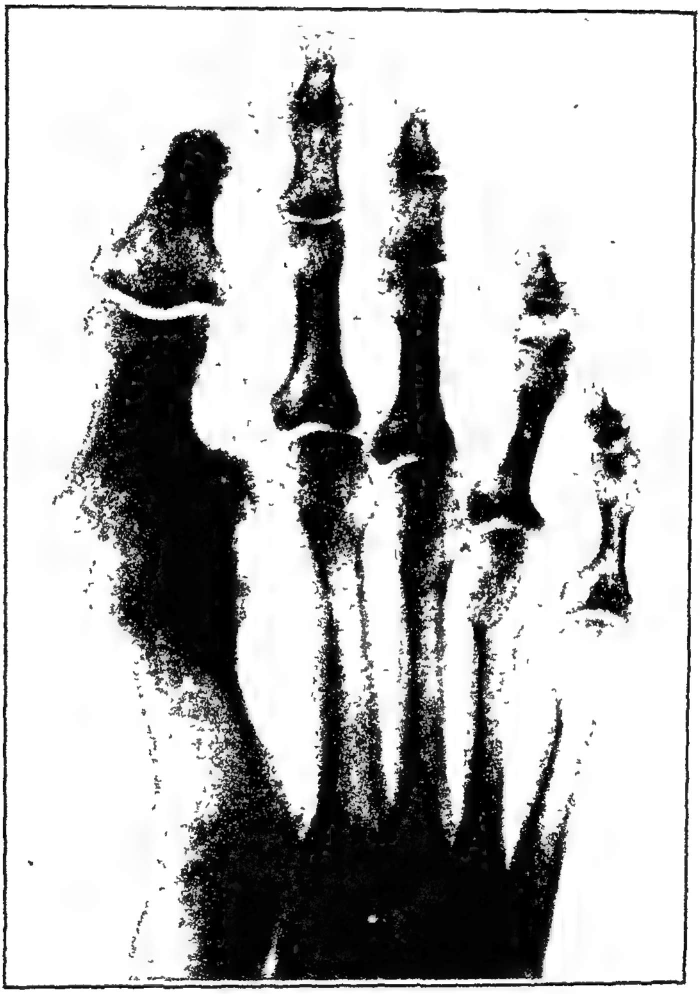


Fig. 273.—A Charcot big toe joint Hypertrophic arthritis Note destruction of joint surfaces.

Sensory disturbances, *i. e.*, analgesia, "tabetic cuirass," hyperalgesia, and delayed transmission of sensation are noted. Wassermann and Kahn tests of the blood and spinal fluid should be made. The spinal fluid examination consists of cytologic, chemical, and the Lange colloidal gold and other tests. The therapeutic test of antisyphilitic treatment is helpful.

The local signs include swelling and absence of sensitiveness.

Roentgen Findings —The most characteristic roentgen finding is extensive destruction of bones, but in the hypertrophic type there is also proliferation of bone Loose bodies are common Atrophy is absent because of the fact that the joint is not painful and is therefore used Roentgenograms reveal a simultaneous destruction of the articular surfaces and of the bones, with an irregular hyperplasia of bone in the surrounding tissues The destruction revealed by the roentgenogram is entirely out of proportion to the clinical findings

Diagnosis —It is necessary to differentiate Charcot's joint, tuberculosis, arthritis, synovitis, osteomyelitis, osteochondritis, aseptic necrosis of bone, fracture, dislocation, malignancy, and septic infection

Treatment —The treatment is stabilization and antisyphilitic medication Stabilization consists of the application of braces or plaster-of-Paris casts, or arthrodesis Removal of the remaining cartilage, and débris, joint resection and immobilization have resulted in benefit in a number of cases Antisyphilitic medication consists of arsphenamine, tryparsamide, bismuth, mercury and iodides

Steindler emphasizes the following (1) the earliest detection of the arthropathic joints by roentgen examination in the pre-ataxic stage even as the first symptoms of oncoming tabes, and (2) immediate and adequate protection of the joint to prevent detrimental external influences *Protection against these influences by early and adequate* splinting, preservation and protecting the musculature by physical therapy, and, above all, early stabilization and alignment by conservative or operative means furnish the best prospects of preserving the usefulness of these joints

PULMONARY OSTEO-ARTHROPATHY

Pulmonary *osteo-arthropathy appears usually during the early* period of life and may or may not be associated with pulmonary tuberculosis It is manifested by periosteal changes in the long bones There is a generalized periostitis with elevation of periosteum and deposition of calcium in it, but not attached to the bone The bones most commonly affected are the metacarpals, metatarsals and phalanges of the hands and feet There is usually no basic bony change, the cartilage is usually intact

In a large proportion of cases a suppurating focus has existed in the chest, from which a toxin has been thought to be derived

Kleinberg reported a case of secondary pulmonary hypertrophic osteo-arthropathy in which the patient developed pathological changes in the extremities as a result of a chronic fibrous pulmonary tuberculosis He had swelling of the distal extremities of all the limbs, most marked in the legs and feet The swelling is due to hyperemia, fibrous tissue thickening of the subcutaneous tissue, and ossifying periostitis

of the long bones. The patient had permanent globular enlargement or clubbing of the distal phalanges of the fingers and toes; parrot beak deformity of the nails of the toes and fingers and subperiosteal deposit of bone along the shafts of the long bones of the extremities.

HEMOPHILIA AND HEMOPHILIC ARTHROSIS

Hemophilia involving the ankle joint is characterized by excessive hemorrhage occurring both spontaneously and following slight trauma. The bleeding is due to marked prolongation of the coagulation time and a marked increase in the resistance of the blood platelets. Hemophilia is an inherited condition transmitted to males through unaffected females. Extravasation of blood occurs into joints, causing pain, bone changes, and disability.

Hemophilic arthropathies may result from minor trauma and tend to recur periodically. As the result of repeated bleeding into the joints, the synovial membrane becomes inflamed, hypertrophic, and infiltrated with iron pigment; the cartilages may become eroded, the articular surfaces hypertrophic, and the capsule and ligaments thickened and fibrotic. The hemorrhage is free into the joint or produces hemorrhagic synovitis. In advanced cases, the roentgenogram shows definite areas of rarefaction. The joint lesions are practically examples of traumatic arthritis.

The stages of the arthropathy are usually: (1) hemarthrosis, (2) arthritis with thickening of the synovia and limitation of joint movement, and (3) deformities or contractions of the joint with loss of movement. A history of trauma is usually elicited. The increase in the size of the joint is rapid and usually not accompanied by severe pain. There is a mild elevation of the temperature, and free fluid is present in the joint. Subcutaneous hemorrhages, when present, facilitate the diagnosis.

In the primarily chronic and recurrent acute cases, permanent joint changes may lead to deformity and ankylosis. Erosion and adhesions between the joint structures may limit or abolish movement.

Roentgen examination shows atrophy of the bones, which is more pronounced in the epiphyses than in the diaphyses. The joint surfaces may be smooth or irregular.

According to Key, bleeding into a joint follows an injury or may occur even without a known injury. It may begin early in life. The joint becomes distended with blood under pressure. As the blood does not clot, it may remain for a long time. The blood acts as an irritant, and hyperplasia of the synovial membrane occurs.

The accumulation of blood pigment in the subsynovial tissue and probably the repeated occurrence of bleeding into a joint under pres-

sure cause irritation which results in the formation of a layer of dense fibrotic connective tissue. Ankylosis is due partly to thickening and shortening of the fibrous capsule and ligaments and partly to the production of new fibrous tissue. Organization and deposition of calcium salts may occur.

FIG. 274.—Hypertrophic pulmonary osteo arthropathy

The roentgen findings are as follows. In the acute hemorrhagic stage there are no changes in the bones, but the blood in the joint casts a shadow which is slightly more dense than that of the usual synovial effusion. In the arthritic stage, there are abnormalities of the soft parts and bones which resemble the changes produced by tuberculosis, hypertrophic arthritis, atrophic arthritis, or traumatic arthritis. Key recognizes as characteristic features, a markedly increased density of the synovial tissue and crater-like depressions or punched-out defects in the intra-articular portions of the bone.

In hemophilic hemarthrosis following a mild trauma the joint rapidly distends. It is warm, but the skin shows no changes in color. There

is slight fever. The joint should be immobilized in a splint for at least ten days, and the patient kept at absolute rest. A transfusion of human blood or fresh animal serum may cause the swelling to disappear in a few days and the joint to regain its normal motion quickly.

When once disturbed, the synovia becomes fragile, the synovial fluid undergoes changes, and fibrous adhesions form with thickening of the joint which limits joint movement. The blood supply of the epiphyses may be endangered.

Usually there are several attacks of hemarthrosis before true chronic arthritis begins.

Early roentgen-ray findings include widening of the joint space and transverse striæ in the bones. The joints are enlarged and feel "doughy."

Prognosis.—The mortality before the fifth year is said to be over 50 per cent, and the mortality before the twentieth year about 90 per cent.

Treatment.—The treatment may be divided as follows:

A. Preventive:
   1. Prevention of transmission of the disease.
   2. Prevention of the accidents that precipitate the onset of a hemorrhagic phase.

B. Treatment of the condition itself:
   1. Attempts to influence the general course of the disease or permanently to change the fundamental defect of the blood, *i. e.*, the coagulation factors.
   2. Treatment during the acute hemorrhagic phase by general and local measures.
   3. Treatment of complications.

Prophylaxis of attacks of bleeding is accomplished by the avoidance of trauma and by proper preparation before any surgical procedure. The best method of preventing and treating acute attacks is the intravenous transfusion of unmodified human blood. Citrated blood produces similar results, but is more apt to produce a reaction. Intramuscular injections of 20 cc. of whole blood are sometimes beneficial. Snake venom is advocated by some authorities.

For acute hemarthrosis, Key recommends absolute recumbency in bed with the joint splinted or immobilized in plaster-of-Paris until the pain ceases and the blood in the joint cavity is largely absorbed. There is a question as to whether or not the joint should be aspirated. When swelling disappears from the joint, function may be resumed, but the patient should be cautioned against indulging in traumatic activities. Radium has produced excellent results.

In the treatment of chronic hemophilic arthritis, Key includes the correction of deformities and support of the involved joints. For

severe hemorrhage, he recommends the transfusion of blood Bernstein recommended the use of whole blood from menstruating women

In the case of hemophilia reported by Kimm and Van Allen, a prolonged period of spontaneous bleeding was terminated by intramuscular injections of ovarian extract Grant also suggested the use of ovarian extract

Reasoning on the hypothesis that if the female can transmit the disease, she must potentially have the disease and there must be something in the female organism which holds the disease in abeyance, Birch treated cases of severe hemophilia with ovarian therapy and ovarian transplantation The results were excellent Birch *found that the urine of patients with severe hemophilia is deficient in* the female sex hormones Of 17 patients receiving ovarian therapy for a period exceeding six months, 15 showed definite clinical improvement, accompanied by shortening of the coagulation time The ankle should be immobilized and subcutaneous injection of anti-diphtheritic serum or blood transfusion should be given monthly

Breaking-up of the adhesions by gentle flexion should be followed by full extension and the application of a plaster gutter-splint Weight-bearing should be forbidden for a long time

CHAPTER XXIV

NEUROLOGICAL LESIONS AFFECTING THE FUNCTION OF THE FOOT AND ANKLE

The purpose of this Chapter is to discuss neurological lesions which cause demonstrable changes in the foot and ankle joint.

It is remarkable how many neurological conditions can be discovered and differentiated by a simple and brief examination of the foot, ankle, and leg. The important reflexes are the Babinski, Achilles, patellar, *Gordon*, *Oppenheim*, and *Chaddock* tests. The equipment required is a pin, percussion hammer, a wisp of cotton, hot and cold water in test tubes and a sense of touch.

A short, simple, but informative neurological examination of the foot and ankle consists in determining the neuro-muscular function of the foot. The first step is to find out whether the patient can voluntarily put his foot in dorsiflexion, plantar-flexion, pronation, and supination; the second, whether these movements can be made passively; the third, whether they can be done against resistance; the fourth, whether there is any inequality or imbalance of muscle power; and the fifth, whether the patient can feel the touch of the hand on all areas of the skin, and whether he can differentiate between the sharp and dull ends of a pin, between the sensation of a wisp of cotton and the stroking of a finger, and between heat and cold applied by means of test tubes containing warm and cold water. The presence or absence of the Babinski reflex is determined by stroking the sole of the foot along its outer border. The proprioceptive sense is determined by moving the toes up and down and sidewise. Ataxia can be easily demonstrated.

It is surprising how often a patient will report minor symptoms of foot disturbances that turn out to be indications of serious neurological lesions. Most of these patients have made the rounds of bootmakers and have tried various stock shoes, with no success. Some of these cases eventually prove to be examples of Charcot-Marie-Tooth type of paralysis, spinal cord tumors and other neurological lesions.

The defect is obvious in the foot only, the person complaining that he is wearing out one side of the shoe or that he is constantly stubbing his toe. The actual defect may be in the muscles, the peripheral nerves, or in the spinal cord. Mild cases cause the greatest diagnostic difficulties.

In the muscle group may be mentioned the myopathies, chiefly the dystrophies with foot-drop, high-arch, peroneal weakness and Achilles tendon contracture. The peroneal type of Charcot-Marie-Tooth belongs in this group. In progressive muscular dystrophy, the pectoral girdle and erectors of the spine are involved.

In the peripheral nerve group the cause for the weakness of foot musculature may have been an unrecognized anterior poliomyelitis, or part of a single or multiple neuritis. Not infrequently patients addicted to alcohol, to dietary fads, or limited in diet by economic stress or by orders of a physician, find their feet "bothering" them. Investigation reveals foot-drop and often sensory defects (deficiency polyneuritis). Lead may be an offender as well as many other poisons and toxins.

Aside from acquired conditions like tumors, inflammations like anterior poliomyelitis, and affections like multiple sclerosis, the spinal cord is the seat of many hereditary and developmental anomalies. An example of the first is Friedreich's cerebellar ataxia with its characteristic high-arched foot. In the second group, mention may be made of occult spina bifida, myelocele, meningocele, and myelodysplasia. Some authorities include syringomyelia in this group. The lesion of the back, either a sac, a tuft of hair, or the roentgen-ray evidence of the deficient closure of the spinal laminae, helps to clinch the diagnosis. The orthopædic surgeon must not forget that the mechanically inadequate foot with a "bunion" that refuses to heal, may be due to tabes dorsalis or syringomyelia with a *mal perforans*. When the spinal cord is the seat of pathological changes, the sphincters of the bladder and rectum, as well as sexual functions, may be involved.

Some of the neurological conditions affecting the foot and ankle include poliomyelitis, spastic paralysis, peripheral neuritis, Friedreich's ataxia, tabes dorsalis, Charcot's disease, central nervous system lesions, spina bifida, peripheral nervous system lesions, paralgia and meralgia hyperesthetica, spinal nerve lesions, causalgia, neuritis and neuralgia, hysteria, exaggeration and malingering.

Spastic paralysis in children may be congenital or acquired. Spastic paralysis in adults may be due to trauma such as a skull fracture, or to arteriosclerosis, cardiac, kidney, or cerebellar diseases, embolism, or thrombosis.

Poliomyelitis and spastic paralysis may affect infants, children, or adults. Among the important neuro-muscular conditions affecting the foot and ankle are: pseudohypertrophic muscular dystrophy, diphtheritic paralysis, peripheral neuritis caused by chemical poisons and infections, and the avitaminoses due especially to deficiency of various vitamins of the B Group.

The spinal cord and brain conditions affecting the foot and ankle are

tumors, injuries and infections. Multiple sclerosis, tabes dorsalis, and hysteria may involve the foot and ankle.

Lesions of the nervous system are divided anatomically and physiologically into those affecting the central and those involving the peripheral nervous systems.

LESIONS AFFECTING THE CENTRAL NERVOUS SYSTEM

I. The Brain.—The brain may be involved in any pathological process such as tumors, injury, vascular disease, degeneration and infection. These lesions may be of varying degrees of severity and may involve any area of the brain.

Any severe lesion of those areas of the cortex of the brain that control the leg, ankle and foot can cause hypertonicity of the gastrocnemius, soleus, flexor digitorum and anterior tibial muscles. A more marked hypertonicity exists in the plantar flexors with resultant talipes equinus deformity and disability. This may be due to prenatal or postnatal factors.

Where the lesion is incapacitating, and known with certainty to be irremedial except by orthopedic procedures such as tendon lengthening, the gastrocnemius and soleus muscles are weakened by section of some of their motor branches from the tibial nerve (Stoffel operation).

The changes wrought by this operation are considered irreversible and the procedure should, therefore, be reserved for those situations which are progressive. It is remarkable to observe how much of the gastrocnemius and soleus muscles may be deprived of their nerve supply and still maintain a persistent equinus.

II. Spinal Cord.—Lesions of the spinal cord may be partial or complete. Partial lesions may cause increased spasticity of the leg musculature or a persistent ankle clonus whenever weight is placed on the ball of the foot. Atropine derivatives are occasionally useful in combating the excessive tonus. Complete lesions of the spinal cord cause spastic paraplegia. Such patients frequently have mass reflexes involving all the muscles of the lower extremities, the bladder and the bowel following slight stimuli. Contractures develop and the patient presents a difficult nursing problem.

Motor impulses to the calf musculature can be interrupted temporarily, where the lesion is not known to be irreversible, or permanently where the lesion is known to be irremedial.

Where the lesion is not known to be of a permanent nature, absolute alcohol may be injected into the subarachnoid space (Dogliotti procedure) in sufficient amounts to cause a flaccid paralysis of the lower extremities. It must be remembered that the alcohol may also attack the sacral segments innervating the bladder and impair or destroy a functioning neurogenic bladder.

When the lesion is known to be permanent, anterior rhizotomy of the involved nerve roots may be performed In this way, a spastic paraplegia is changed to a more favorable flaccid paraplegia Careful identification of the nerve roots to be sectioned precludes any disturbance of bladder function Under similar circumstances, the tibial nerve may be sectioned completely in the popliteal space and immediately resutured accomplishing the same objective Where the spasticity is not severe, only one or two motor branches may be sectioned as described above If the mass reflex involves musculature above the knee, sectioning the tibial nerve will not be sufficient

III Lesions of the Cauda Equina—These lesions cause a flaccid paralysis of the lower extremities with a flail ankle This necessitates a strong bilateral brace with a spring attachment to counteract the foot drop caused by gravity

Lambrinudi's operation may be beneficial

If the neurological lesion cannot be successfully treated *fusion of the ankle joint* may be necessary

PERIPHERAL NERVE LESIONS

It has been shown that when the sciatic nerve is severed, there is a paralysis of all the muscles below the knee Because the fibers to the biceps femoris, semimembranosus, and semitendinosus are given off high in the thigh, they are often spared There is a loss of sensation over the outer side of the leg and over the whole foot except the inner surface proximal to the sole

When the peroneal nerve is severed, the foot hangs in a plantar-flexed position known as "foot-drop" (Fig 275) The patient is unable to flex or extend the toes or the foot, or to evert the foot Inversion is possible by feeble action of the tibialis posticus, supplied by the tibial nerve The sensory loss extends over the outer side of the leg, a strip over the dorsum of the foot, from the inner two or two and a half toes to a line in the middle of the outer surface of the great toe, and the great and adjacent toe Because of overlap, a very narrow strip over the dorsum of the foot is sometimes the only area completely anesthetic to all sensation

Irremediable defects in nerves may be treated by tendon and muscle transplantation, and arthrodesis of joints

When a nerve has only been compressed by scar tissue or a bony callus, it may be dissected free and placed in a new bed This procedure is known as "neurolysis" The operation is indicated in cases in which the lesion is chiefly extraneural and is most successful when the nerve is compressed by a constricting band Sometimes after the scar tissue around the nerve has been removed, the nerve is found to be indurated

tumors, injuries and infections. Multiple sclerosis, tabes dorsalis, and hysteria may involve the foot and ankle.

Lesions of the nervous system are divided anatomically and physiologically into those affecting the central and those involving the peripheral nervous systems.

LESIONS AFFECTING THE CENTRAL NERVOUS SYSTEM

I. The Brain.—The brain may be involved in any pathological process such as tumors, injury, vascular disease, degeneration and infection. These lesions may be of varying degrees of severity and may involve any area of the brain.

Any severe lesion of those areas of the cortex of the brain that control the leg, ankle and foot can cause hypertonicity of the gastrocnemius, soleus, flexor digitorum and anterior tibial muscles. A more marked hypertonicity exists in the plantar flexors with resultant talipes equinus deformity and disability. This may be due to prenatal or postnatal factors.

Where the lesion is incapacitating, and known with certainty to be irremedial except by orthopedic procedures such as tendon lengthening, the gastrocnemius and soleus muscles are weakened by section of some of their motor branches from the tibial nerve (Stoffel operation).

The changes wrought by this operation are considered irreversible and the procedure should, therefore, be reserved for those situations which are progressive. It is remarkable to observe how much of the gastrocnemius and soleus muscles may be deprived of their nerve supply and still maintain a persistent equinus.

II. Spinal Cord.—Lesions of the spinal cord may be partial or complete. Partial lesions may cause increased spasticity of the leg musculature or a persistent ankle clonus whenever weight is placed on the ball of the foot. Atropine derivatives are occasionally useful in combating the excessive tonus. Complete lesions of the spinal cord cause spastic paraplegia. Such patients frequently have mass reflexes involving all the muscles of the lower extremities, the bladder and the bowel following slight stimuli. Contractures develop and the patient presents a difficult nursing problem.

Motor impulses to the calf musculature can be interrupted temporarily, where the lesion is not known to be irreversible, or permanently where the lesion is known to be irremedial.

Where the lesion is not known to be of a permanent nature, absolute alcohol may be injected into the *subarachnoid space* (Dogliotti procedure) in sufficient amounts to cause a flaccid paralysis of the lower extremities. It must be remembered that the alcohol may also attack the sacral segments innervating the bladder and impair or destroy a functioning neurogenic bladder.

When the lesion is known to be permanent, anterior rhizotomy of the involved nerve roots may be performed. In this way, a spastic paraplegia is changed to a more favorable flaccid paraplegia. Careful identification of the nerve roots to be sectioned precludes any disturbance of bladder function. Under similar circumstances, the tibial nerve may be sectioned completely in the popliteal space and immediately resutured accomplishing the same objective. Where the spasticity is not severe, only one or two motor branches may be sectioned as described above. If the mass reflex involves musculature above the knee, sectioning the tibial nerve will not be sufficient.

III Lesions of the Cauda Equina.—These lesions cause a flaccid paralysis of the lower extremities with a flail ankle. This necessitates a strong bilateral brace with a spring attachment to counteract the foot drop caused by gravity.

Lambrinudi's operation may be beneficial.

If the neurological lesion cannot be successfully treated *fusion of the ankle joint* may be necessary.

PERIPHERAL NERVE LESIONS

It has been shown that when the sciatic nerve is severed, there is a paralysis of all the muscles below the knee. Because the fibers to the biceps femoris, semimembranosus, and semitendinosus are given off high in the thigh, they are often spared. There is a loss of sensation over the outer side of the leg and over the whole foot except the inner surface proximal to the sole.

When the peroneal nerve is severed, the foot hangs in a plantarflexed position known as "foot-drop." (Fig. 275.) The patient is unable to flex or extend the toes or the foot, or to evert the foot. Inversion is possible by feeble action of the tibialis posticus, supplied by the tibial nerve. The sensory loss extends over the outer side of the leg, a strip over the dorsum of the foot, from the inner two or two and a half toes to a line in the middle of the outer surface of the great toe, and the great and adjacent toe. Because of overlap, a very narrow strip over the dorsum of the foot is sometimes the only area completely anesthetic to all sensation.

Irremediable defects in nerves may be treated by tendon and muscle transplantation, and arthrodesis of joints.

When a nerve has only been compressed by scar tissue or a bony callus, it may be dissected free and placed in a new bed. This procedure is known as "neurolysis." The operation is indicated in cases in which the lesion is chiefly extraneural and is most successful when the nerve is compressed by a constricting band. Sometimes after the scar tissue around the nerve has been removed, the nerve is found to be indurated

In such a case, the sheath of the nerve must be incised (internal neurolysis). Severance of some of the funiculi may necessitate suture of part of the nerve. In cases of extensive injury, resection and suture may be indicated.

Following an injury to a nerve, before operation is performed and following the operation until recovery has occurred, overstretching of the paralyzed muscles and overaction of unopposed muscles, leading to deformities, must be prevented by proper splinting. The extremities should be splinted to place the muscle at rest, usually mid-way between its extremes of movement. Physical therapy directed toward the prevention of fibrosis, capsular contraction of joints, and fibrosis and atrophy of muscles should be used before and after operation. This should consist of heat, massage, passive movement, electrical stimulation of paralyzed muscles, and later reeducational exercises.

FIG. 275.—Paralysis of common peroneal nerve producing foot-drop or paralytic equinus

Peripheral neuritis and neuropathy may be due to infection, injury, metabolic disturbances, changes of temperature and moisture or to chemicals. The pathological changes are swelling due to edema, hemorrhage and round cell infiltration in the dorsal intervertebral sensory ganglions and in the gray matter of the spinal cord. The symptoms are local and referred pain, tenderness to touch and sensitiveness to movement. Circulatory changes are common. Muscular

weakness may be marked, and paralysis may occur The differential diagnosis includes local and general infections, arthritis, acute rheumatic fever, chronic rheumatism, circulatory and skin disturbances, muscle and tendon inflammation, bursitis and poliomyelitis The treatment includes protection of the member, search for the etiological factors and their removal, physical therapy and splinting The peripheral neuritis found in beri beri is due to vitamin B deficiency

PERIPHERAL NERVE WOUNDS OF THE LOWER EXTREMITY

Complete interruption of any peripheral nerve results in

1 Loss of motor power of the muscles supplied by the nerve
2 Complete loss of sensation in the sensory distribution of the nerve
3 Atrophy of the muscles supplied by the involved nerve
4 Trophic changes in the skin and its appendages due to interruption of the sympathetic supply traveling along the peripheral nerve
5 Generally, the formation of a tender neuromatous bulb on the proximal end of the cut nerve
6 Loss of the deep tendon reflexes in the tendon innervated

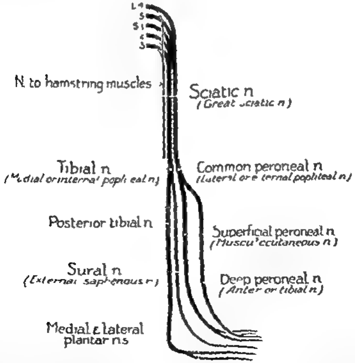


FIG 276 —Diagram of the divisions and branches of the sciatic nerve The nerve to the hamstring muscles is incorporated in the sciatic trunk The tibial nerve becomes the posterior tibial at the upper border of the soleus muscle (indicated by broken lines) Synonyms for the various nerves are included (Haymaker and Woodhall courtesy of W B Saunders Company)

Partial interruption by injury of a peripheral nerve yields similar results to a greater or lesser degree. Also, it occasionally causes the production of severe pain of a burning nature, called causalgia.

In paralysis of the great sciatic nerve, one is unable to (1) balance on the affected side; (2) flex his knee; (3) extend his thigh; (4) raise his foot; (5) rise on his toes; and (6) to "beat time" with the foot of the affected side.

In internal popliteal nerve paralysis one is unable to "point his toe;" to adduct his foot; to flex and separate his toes. The calf group becomes flabby and the tendo Achillis loses its prominence.

In external popliteal nerve paralysis, a drop-foot appears and one is unable to raise his foot. Signs of recovery from external popliteal nerve paralysis are similar to those described under sciatic paralysis.

THE SCIATIC NERVE AND ITS BRANCHES

Anatomy.—At a variable distance above the popliteal fossa, the sciatic nerve terminates by dividing into two branches: the tibial and common peroneal. The following description is taken from Haymaker and Woodhall:

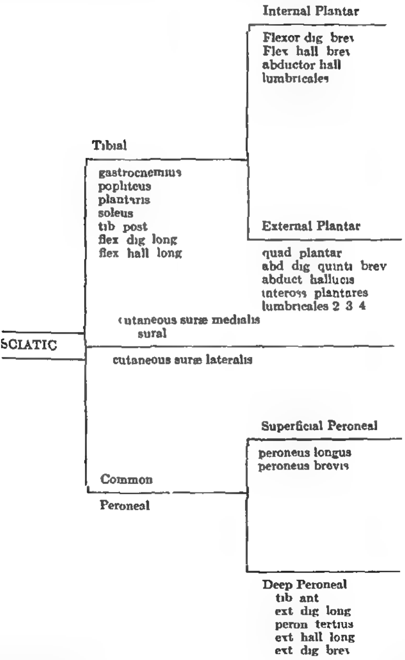
The tibial nerve gives off the sural, which extends down the back of the leg to the outer side of the foot. At the upper level of the soleus muscle the tibial goes over into the posterior tibial nerve which, on reaching the sole of the foot divides into medial and lateral plantar nerves. The common peroneal nerve divides into superficial peroneal and deep peroneal, both of which ultimately reach the dorsum of the foot.

The Tibial Nerve.—The tibial nerve is derived from all the undivided anterior primary rami of the sacral plexus. It becomes separated from its fellow, the common peroneal, at a variable distance above the popliteal fossa. The nerve extends downward in the middle of this fossa to the upper level of the soleus muscle. En route it gives off branches to the following muscles: gastrocnemius (both heads), plantaris, soleus, popliteus and usually tibialis posterior. It also supplies a cutaneous branch, the sural, which reaches the skin by piercing the deep fascia in the middle third of the back of the leg. It continues downward and, on reaching the ankle, gives off the lateral calcanean nerve to the heel; it then rounds the back of the lateral malleolus to enter the foot. The cutaneous distribution of this nerve is shown in Figure 277.

The Posterior Tibial Nerve.—The posterior tibial nerve is a continuation of the tibial. It starts at the level of the fibrous arch of the soleus. In its course downward, the nerve rests on the tibialis posterior muscle as well as on the tibia, then continues between the flexor digi-

torum longus and flexor hallucis longus. The nerve terminates under the flexor retinaculum (behind and inferior to the medial malleolus) by dividing into the lateral and medial plantar nerves. The nerve supplies the soleus, tibialis posterior, flexor digitorum longus and flexor hallucis longus. The only cutaneous branch is the medial calcanean nerve, which supplies the corresponding part of the heel.

NERVES OF LOWER EXTREMITY



The Lateral and Medial Plantar Nerves.—The terminals of the posterior tibial nerve are the lateral plantar nerve, and the medial

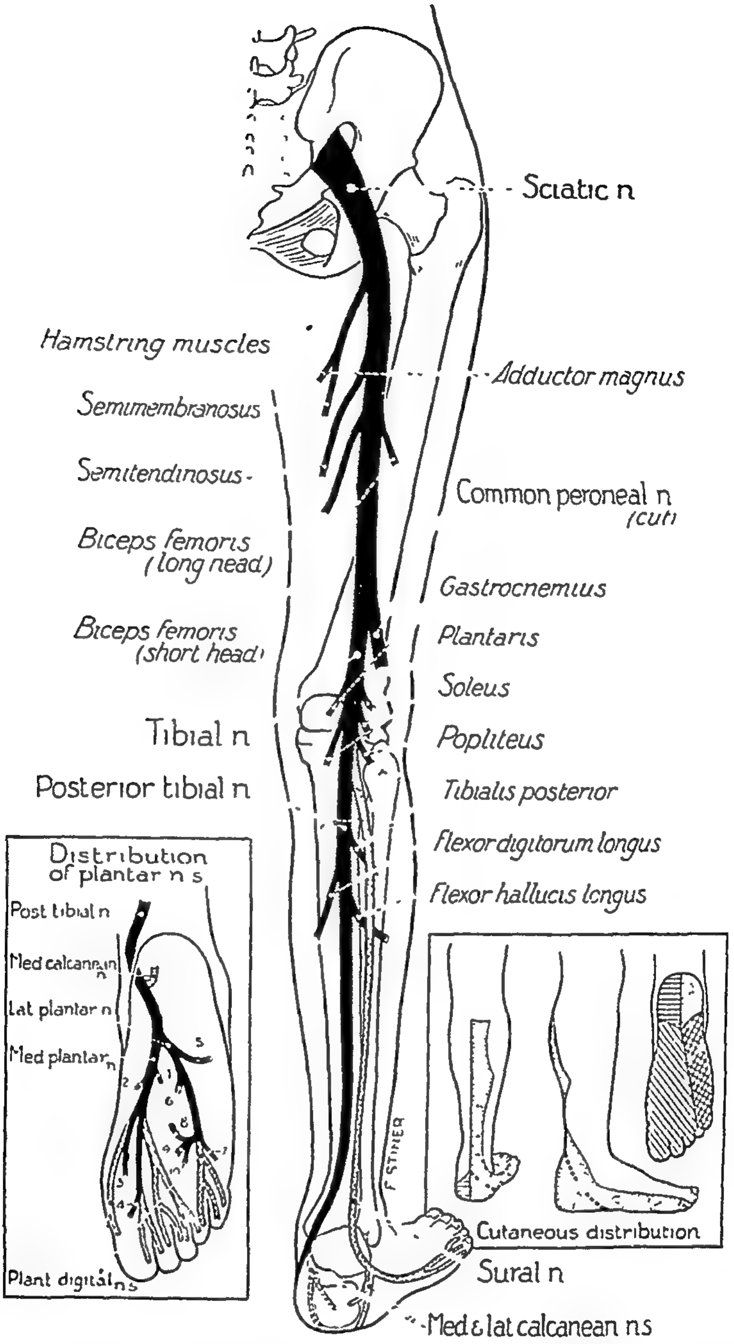


FIG. 277.—The course and distribution of the sciatic, tibial, posterior tibial and plantar nerves. A dotted line marks the transition between tibial and posterior tibial nerves. The cutaneous fields of the medial calcanean and medial plantar nerves are indicated in the inset by lines, the field of the sural nerve and its lateral calcanean branch by dots; and that of the lateral plantar nerve, by crosshatch. The names of the muscles supplied are italicized. The numbered branches of the plantar nerves are as follows. 1, flexor digitorum brevis, 2, abductor hallucis; 3, flexor hallucis brevis; 4, first lumbrical, 5, abductor digiti quinti; 6, flexor digitorum accessorius, 7, flexor digiti quinti brevis; 8, adductor hallucis; 9, interossei; 10, 2nd, 3rd and 4th lumbricals (Haymaker and Woodhall, courtesy of W. B. Saunders Company.)

plantar Their muscular and cutaneous supplies are indicated in the legend of Figure 277 These nerves also supply the distal part of the dorsal surfaces of the toes as well as the toenails

The Common Peroneal Nerve—Incorporated in the common peroneal, are fibers of spinal segments L4, L5, S1, and S2 Commencing in the lower part of the thigh, it courses downward along the lateral

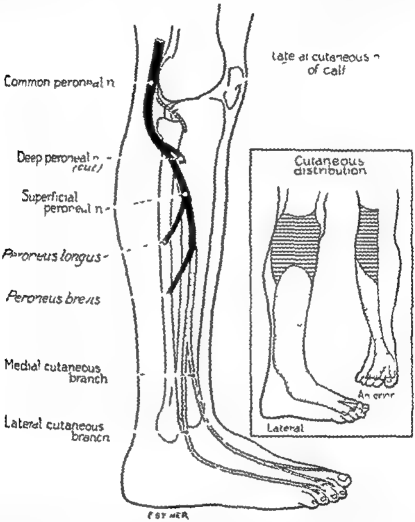


FIG 278—The course and distribution of the superficial peroneal nerve The names of the muscles innervated are in italics The dotted pattern in the inset indicates the cutaneous field of the superficial peroneal nerve the lined pattern that of a branch of the common peroneal nerve the lateral cutaneous nerve of the calf (Haymaker and Woodhall courtesy of W B Saunders Company)

border of the popliteal fossa to reach the back of the head of the fibula It winds round the neck of the fibula, whereupon it divides into the superficial and deep peroneal nerves The nerve gives off one branch of consequence the lateral cutaneous nerve of the calf, whose distribution is indicated in Figure 278

The Superficial Peroneal Nerve—The superficial peroneal nerve begins at the level of the bifurcation of the common peroneal, i e,

just below the neck of the fibula. It descends in front of the fibula, coursing between the peronei and extensor digitorum longus. In the lower third of the leg it divides into two branches which become cutaneous by piercing the deep fascia. Both run downward to supply the skin of the front and side of the leg and dorsum of the foot—in the areas indicated in Figure 278. The nerve gives off branches to the peroneus longus and peroneus brevis muscles.

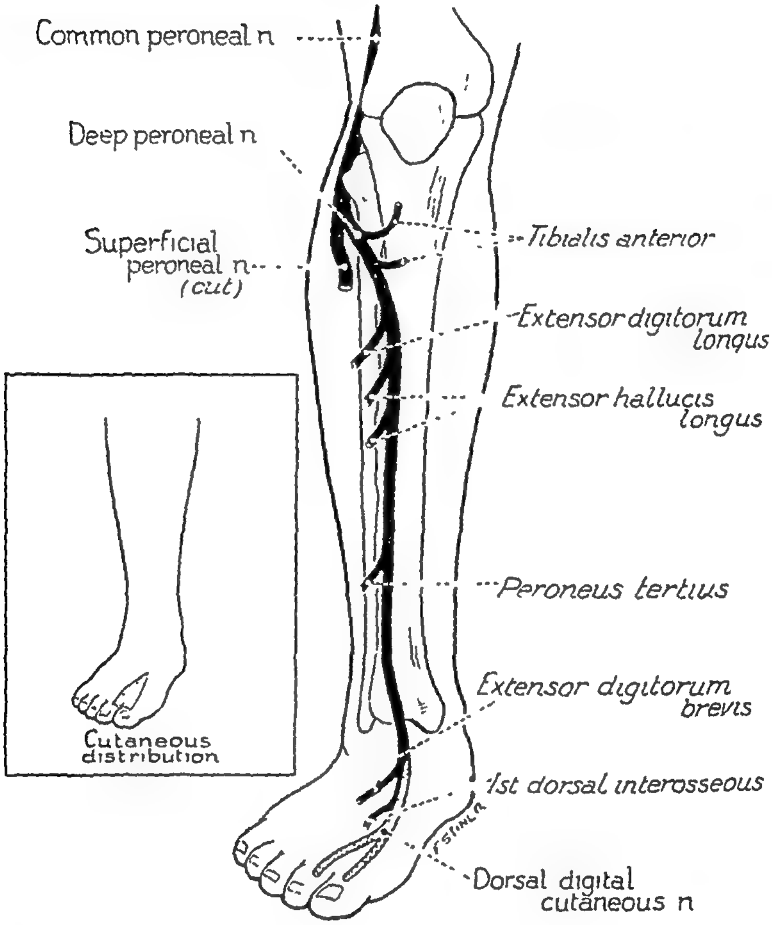


FIG 279.—The course and distribution of the deep peroneal nerve. The muscles supplied are indicated in italics. The cutaneous distribution of the nerve is shown in the inset (Haymaker and Woodhall, courtesy of W. B. Saunders Company.)

The cutaneous nerve supply of the dorsum of the foot is subject to considerable variation. Frequently the superficial peroneal innervates all toes except the lateral half of the fifth. In some instances the sural nerve takes over much of the field of the lateral cutaneous branch of the superficial peroneal nerve.

The Deep Peroneal Nerve.—This nerve begins just below the head of the fibula. It winds round the neck of the fibula, arriving at the front of the leg, where it pursues its course on the interosseous membrane and on the distal part of the tibia. Reaching the ankle it passes

under the superior extensor retinaculum, arriving at the foot where it divides into medial and lateral branches, the former extends to the skin of the lateral side of the great toe, the medial side of the second toe and the first dorsal interosseous muscle, while the latter reaches the extensor digitorum brevis The deep peroneal nerve and its branches supply the following muscles tibialis anterior, extensor hallucis longus, extensor digitorum longus, peroneus tertius, first dorsal interosseous muscle and extensor digitorum brevis

INJURIES

Injuries of the Common Peroneal Nerve and Its Branches —Of all the sciatic branches, the common peroneal is most liable to injury

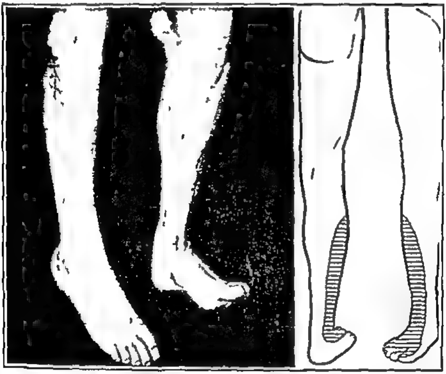


FIG 280 —Common peroneal nerve palsy right Fracture of the neck of the fibula and "stretch" injury to the common peroneal nerve occurred when this soldier fell into a gulley to avoid strafing Among other movements dorsiflexion of the foot and toes cannot be performed The sensory deficit is in the fields of the superficial and deep peroneal nerves Sural plantar nerves and other branches of the tibial have escaped damage (Haymaker and Woodhall courtesy of W B Saunders Company)

Even when there is direct trauma to the sciatic trunk the common peroneal usually is affected more than the tibial The nerve may be seriously injured not only by gunshot wounds but also by the stretching subsequent to fracture of the head of the fibula and by rupture of the lateral collateral ligament, moreover, it is peculiarly sensitive to pressure exerted on the head of the fibula, for instance, that caused by a tightly applied plaster cast

The deep peroneal nerve (anterior tibial) supplies the dorsiflexors of the foot and the extensors of the toes. Consequently, interruption of this nerve leads to foot-drop; efforts to raise the foot or to elevate the toes are unavailing (Fig. 280). In determining the power of dorsiflexion at the ankle it is important that the foot first be lifted into a dorsal position before the testing is done, for although the foot is incapable of dorsiflexion from the plantar position it may retain its dorsal position against gravity.

If the superficial peroneal nerve is intact and its muscles (peroneus longus and brevis) are working unopposed, the foot tends to evert when the patient walks. In time pes valgus may develop.

When the deep peroneal nerve is divided below the point where branches are given off to the tibialis anterior and the extensor digitorum longus, the patient can perform all movements adequately except elevation of the great toe. Involvement of the extensor digitorum brevis may be detected by electrical tests. Sensory deficit often occurs in the region between great and second toe.

The superficial peroneal nerve (musculocutaneous) supplies the muscles of the side of the leg, the peroneus longus and brevis, which evert the foot. After interruption of this nerve, eversion can no longer be performed. Dorsiflexion is possible but in the course of the movement the foot tends to become inverted. In longstanding cases the foot may acquire an equinovarus position.

Sensory loss is usually confined to the more medial part of the dorsum of the foot, leaving the cutaneous fields of deep peroneal and sural intact, but it may also be detected on the lateral aspect of the lower leg.

In injuries of the common peroneal nerve (lateral, or external popliteal nerve), the clinical picture is the sum of those which follow injuries to the deep and superficial peroneal nerves. Owing to loss of dorsiflexion and eversion at the ankle, the foot hangs down, often assuming the equinovarus position; the inversion, which is due chiefly to the unopposed action of the tibialis posterior, is not to be construed as evidence that the tibialis anterior is contracting. This possibility may be easily ruled out by noting the loss of ability to dorsiflex at the ankle, which under normal conditions is induced by contraction of the tibialis anterior. Another feature of palsy of the common peroneal nerve is that of loss of power to straighten or elevate the toes. Frequently the toes become extended at the metatarsal joints and flexed at the phalangeals (claw-foot). What is known as "steppage" gait results; the distal part of the foot and its outer margin drag, and at the end of the excursion the foot tends to strike the ground with an audible "clop."

Sensory deficit usually is encountered in the dorsum of the foot and outer side of the leg

Injuries of the Tibial Nerve and Its Branches —Since the tibial nerve supplies muscles of the back of the leg and the sole of the foot, an interruption of the nerve makes plantar flexion of the foot and toes impossible

Complete posterior tibial nerve palsy entails the loss of function of flexor digitorum longus and flexor hallucis longus and of muscles of the plantar surface of the foot Usually the most striking finding in early cases is that of sensory loss over the plantar surface of the foot In time the small muscles of the foot undergo atrophy, increasing the concavity of the plantar arch (pes cavus) and otherwise altering the foot contours

When interruption of the posterior tibial nerve occurs distal to the level where muscular branches are given off, changes usually are encountered only on the sole of the foot These changes consist of complete sensory loss and anhidrosis On occasion, claw-foot may develop, distal toe joints are plantar flexed (by the flexor digitorum longus) while the metatarsophalangeal ones are dorsiflexed (unopposed action of the extensors in conjunction with paralysis of the interossei)

In palsy of the tibial nerve (medial, or internal popliteal) similar changes may be observed Inability to plantarflex the foot also is noted, though on occasion this movement may be performed by means of the peroneus longus Another characteristic of tibial nerve palsy is that of loss of plantar flexion of the toes but this movement may be induced by strongly dorsiflexing the foot, thereby stretching the flexor tendons Inversion at the ankle is merely impaired (paralysis of the tibialis posterior muscle) since in this movement the anterior tibial muscle participates In combined tibial and common peroneal palsy the ability to invert the foot is lost

The patient experiences difficulty in getting his heel off the ground in walking The gait is shuffling and the steps are devoid of spring Injuries of the more proximal part of the tibial nerve tend to involve certain elements of the nerve more than others the small muscles of the foot, the flexor digitorum longus and the tibialis posterior are likely to be affected, in that order (Foerster)

If the lesion is below the point where the sural (external saphenous) nerve is given off, sensory loss usually is encountered over the more medial part of the plantar surface of the foot and over the distal third of the side of the leg, if above this level, sensory loss will encompass the lateral edge of the foot as well Occasionally the sural nerve bears the brunt of an injury

Injuries of the Sciatic Nerve —Injuries of the sciatic nerve are frequent in combat They usually are due to direct gunshot wounds

but may occur in association with fracture of the femur. Regardless of the type of trauma, the peroneal component of the sciatic usually suffers more damage than the tibial. Sometimes they are affected equally, and occasionally only tibial elements are involved. In acute injury of the sciatic nerve, the leg is for a time completely paralyzed; hence, precise localization of the lesion should not be attempted until after a week or two of recovery.

Total Interruption.—When total interruption of the sciatic from battle wounds occurs much of the leg becomes useless. Ability to flex and extend at ankle and toe joints and power of eversion and inversion of the foot are lost. The position of talipes equinus inevitably is assumed and frequently a "flail movement" can be produced at the ankle. Flexion at the knee is greatly impaired, the only muscles still participating in the movement being the sartorius and gracilis.

Extension at the knee is unimpaired by interruption of the sciatic nerve. Thigh movements are unaffected except for extension at the hip which may be slightly weakened. The ensuing atrophy leads to "spindle-leg." The patient is able to stand, but when he walks his gait is peculiar in that he flexes unduly at the hip in order to bring the dropped foot clear of the ground.

Sensibility below the knee is lost except along the inner side of the leg and ankle, which is innervated by the saphenous nerve.

Interruption of the Tibial and Peroneal Components of the Sciatic Nerve With Preservation of the Nerve to the Hamstrings.—Loss of function of, or damage to, this combination of nerves is common In these cases flexion at the knee is, for all practical purposes, preserved.

Simple Tests of Nerve Trunk Injuries have been described by Spurling and Matson as follows:

Lower Extremity.—Observations are limited to simple contractions of the long flexors and extensors of the toes and movements of the foot. Injuries of the lower extremity which involve peripheral nerves are most frequent high in the thigh and at the level of the knee. In the former location either or both divisions of the sciatic nerve may be involved. In the latter the common peroneal nerve is damaged most frequently. Because of this, examination of the toes will give valuable information in the majority of cases. The only common nerve injury apt to be missed, if careful study of toe motion is made, is the posterior tibial nerve, in fractures and shrapnel wounds of the lower third of the leg. In this lesion only the intrinsic musculature of the foot is paralyzed and very little disability results except that which may follow anesthesia of the sole of the foot.

Common Peroneal Nerve Injury.—If there is interruption of the common peroneal nerve to its deep branch, proximal to the middle of

the lower leg, the terminal phalanx of the great toe is extended on the first metatarsal. This action can be produced only with good contraction of the extensor hallucis longus whose tendon can readily be palpated over the dorsum of the first metatarsophalangeal joint. It is supplied by the deep branch of the common peroneal nerve at the proximal third of the lower leg. If this position of the toe cannot be maintained, in the absence of local injury to the tendon or the toe, further examination is unnecessary to establish functional impairment of the peroneal nerve.

Further evidence may be obtained by inability to dorsiflex or evert the foot at the ankle (i.e., foot-drop). These functions are accomplished respectively by the tibialis anticus and the peronei longus and brevis which are innervated by branches of the common peroneal nerve arising in the proximal third of the lower leg.

Tibial Nerve Injury.—If there is interruption of the tibial nerve proximal to the middle of the lower leg, the terminal phalanx of the great toe is flexed on the proximal and the latter is flexed on the first metatarsal. This action can be produced only with good contraction of the flexores hallucis longus and brevis. These muscles are supplied by the tibial nerve in the proximal third of the lower leg. If this position of the toe cannot be maintained, in the absence of local injury to the tendon or the toe, further examination is unnecessary to establish functional impairment of the tibial nerve.

Further evidence may be obtained by inability to plantarflex or adduct the foot at the ankle. These functions are accomplished respectively, by the gastrocnemius group and the tibialis posticus which are innervated by branches of the tibial nerve arising in the proximal third of the lower leg.

Spurling and Matson found that in acute war injuries to the leg, brief examination of voluntary muscle action in the foot is usually possible.

When the lower extremity has been encased in splints or plaster casts, valuable information regarding peripheral nerve damage and recovery may still be obtained by study of voluntary action of the exposed toes, particular emphasis having been placed on the action of the great toe.

These simplified tests, if used generally, should expedite definitive treatment of peripheral nerve casualties.

Transplantation of the External Peroneal Nerve.—The external peroneal nerve is frequently injured because of its superficial course around the head of the fibula. Treatment is difficult if the secondary changes cause continual pressure over the nerve.

Peroneal palsy as an occasional complication associated with fractures about the knee is called to attention by Milch. It is due to

direct contusion traction or pressure against the nerve. It may be due to the improper application of adhesive plaster to the leg or a plaster-of-Paris cast even in the absence of fracture.

Platt called attention to the fact that this nerve may exhibit paralytic phenomena as a result of clinical conditions associated with excessive traction. These may include instances arising as a consequence of accident or trauma incidental to the operative correction of genu valgum. In 1928 Platt emphasized his belief that the nerve lesion is a concomitant of fractures of the styloid process as contrasted with fractures of the neck of the fibula, although it is stated that "the external popliteal nerve lesion which accompanies separation of the fibular styloid, is a true primary injury which bears no casual relation to the treatment of the fracture."

In 1931, Watson-Jones reported the case of a man who had been knocked down by a motor car, and suffered an avulsion of the styloid process of the fibula, with incomplete paralysis of the external popliteal nerve (common peroneal). During operation to reduce the fracture, the peroneal nerve was "found not to have been ruptured, although recent hemorrhage into the sheath was evident. The styloid fragment was replaced and sutured with braided silk, and ten weeks later, when the plaster was removed the paralysis had completely disappeared."

In 1940, Platt described the palsy as an intrinsic part of the "ligamentous peroneal syndrome characteristic of adduction injuries of the knee joint." The syndrome is a combination form, manifested by the presence of peroneal paralysis and by a triad of signs characteristic of adduction injuries to the knee joint, *viz.:* rupture of the lateral capsule, avulsion of the styloid process of the fibula, and avulsion of the biceps tendon from the fibular attachment.

Excessive traction on the peroneal nerve, with resulting paralysis, may be removed by the operation of anterior transposition of the nerve, after the tibial head of the peroneus longus muscle has been detached. In those cases in which simple transposition is insufficient, resection of the fibular head offers a means of overcoming a relative disproportion between the length of the nerve and the tibiofibular distance.

Transplantation of this nerve has been done by Hudson in 4 cases with relief of all symptoms. Because of the anatomical situation of the nerve, the head, neck, and upper 1 inch of the fibula were excised. The nerve was then transplanted into this defect without tension Resection of the upper portion of the fibula permits the peroneal nerve to take a shorter route, thus securing the relative increase in nerve length demanded in the surgical correction of genu valgum

This situation finds an analogy in the case of ulnar palsy that is

relieved by transplantation of the ulnar nerve from its groove behind the elbow into the soft muscle space in front of the medial epicondyle

NEUROMUSCULAR ELECTRODIAGNOSIS

Electrodiagnosis is rapid, exact, and independent of the patient's cooperation. Licht catalogues briefly those tests which are of greatest value. All examinations listed can be conducted with any simple apparatus which delivers the galvanic and faradic currents. Whenever possible, the patient should be recumbent and the examiner seated.

Normal faradic response is a tonic contraction for the duration of current flow. If increased current does not elicit a contraction, it should be *still further* increased to the point of pain. *If there is still* no contraction of the stimulated muscle, reaction of degeneration (R D) is diagnosed. Confusion may result from intense faradic stimulation when the spread of current will contract neighboring muscles. Close scrutiny will show that these are frequently antagonists. If the response to strong faradic stimulation is weak but definite (compared with opposite side) a diagnosis of partial reaction of degeneration is made (P R D). P R D is seen in disease of part of a nerve, such as a partially sectioned nerve or during the gradual return of nerve function.

When muscle bellies are close to each other, it is sometimes difficult to determine which one is responding to the stimulation. In such cases instead of relying on joint motion, the tendon of insertion should be palpated during the contraction. If a muscle responds to faradic stimulation, its nerve segment is intact.

There are several diseases in which muscle-nerve testing is a great aid in differential diagnosis.

DIFFERENTIAL DIAGNOSIS

Hysterical Paralysis.—This condition is usually apparent to the physician from the history of onset and course and the bizarre clinical features. Absence of R D completes the diagnosis and is usually the first step toward recovery because the patient sees his limbs move, and if the current is made sufficiently strong he will dislike it to the point of getting well. The presence of R D would immediately negate the diagnosis of hysteria in the nerves involved.

Myasthenia Gravis.—The muscle will respond to each stimulus with a diminishing contraction until contractions cease. This will occur in from twenty seconds to a few minutes. If contractions continue for more than ten minutes, the test is negative. Even the use of prostigmine will not invalidate the test although it will prolong the pre-fatigue period somewhat.

Poliomyelitis.—In the early phases, involved muscles will show R.D. or P.R.D. depending upon the extent of the lesion. In some patients whose muscles are severely involved there may not be any contraction with either galvanic or faradic stimulation.

Polyneuronitis.—In this group are included those patients with symptoms of marked peripheral nerve shock associated with generalized toxic reaction. Electrical examination is usually made difficult by the increased sensitivity of the skin to electrical and other stimuli. The muscles may show a peculiar distribution of R.D. and P.R.D. Two muscles may appear equally involved yet one will show R.D. and the other will respond normally. As the recovery period progresses, the skin hypersensitivity diminishes and R.D. where present, changes to P.R.D. during recovery.

Neuroarthropathies.—The arthropathies are a group of pathological joint lesions caused by impairment of sensory nerve function and characterized by swelling, hypermobility, crepitus, poor stability and an unusual freedom from pain or tenderness. They may be divided into neurotraumatic, infectious and metabolic. In this chapter the neurological and traumatic arthropathies are the most interesting.

Neuroarthropathies of peripheral nerve injury origin occur with more frequency than is usually believed. These neuroarthropathies are often misinterpreted on account of the absence of demonstrable disease of the central system and extensive joint operations may be performed unnecessarily. The possibility of neuroarthropathy should always be considered in obscure or ill-defined joint manifestations, even in the absence of demonstrable spinal cord disease.

World War I, with its rich array of neurological material and peripheral nerve injuries, proved that the so-called Charcot's joint, or the neuro-arthropathy, could exist independently of disease of the central nervous system. The incidence of these injuries, due to peripheral nerve injury, is high.

Shands reported a case of traumatic neuro-arthropathy of the ankle due to injury of a peripheral nerve.

Charcot believed that the joint change resulted from destruction of trophic fibers in the spinal cord.

The association of bony changes, limited principally to joint structures, with serious disease of the central nervous system has been observed for a great number of years. The recognition of such structural osseous anomalies occurring in the course of tabes dorsalis and syringomyelia were first described accurately by Charcot. Thus the term Charcot joint was interpreted as a destructive arthritic process dependent on and secondary to a disease process of certain fiber tracts in the spinal cord parenchyma.

Wile and Butler find that the greatest age incidence in Charcot's

arthropathy occurs between thirty-five and fifty-five years The mode of onset is gradual and insidious, and extends over a period of months or years The occasional, apparently sudden, development is frequently the result of trauma bringing into view an existing subclinical process Charcot's arthropathy occurs three times more frequently in men than in women Polyarticular involvement is common, no joint being

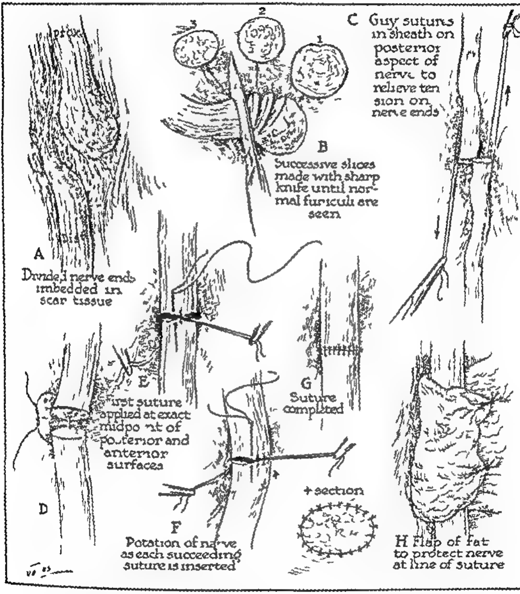


FIG 281 —Technic of nerve repair (Courtesy of Johnson & Johnson)

immune, but the knee and ankle involvement occur far more commonly than do any other forms Cerebrospinal syphilis is present in the majority of the cases Its absence, however, in typical cases indicates that syphilis is not the essential primary etiological factor

Causalgia —The first case of causalgia was reported in 1813 by Denmark, but it was not until 1864 that S Weir Mitchell gave a com-

plete and classic description. Causalgia (thermalgia) is an intensely painful neuro-circulatory condition almost entirely limited to certain sensory areas of the distribution of the median and sciatic nerves. It is caused by lesions of these nerves at points more or less distant from the areas mentioned, and characterized by local vasomotor disturbances and general hypersensitiveness of the nervous system.

This condition may occur in the upper or lower extremity affecting chiefly the median and the internal popliteal nerves. It is characterized by intense pain which is increased by palpation, movement or any slight pressure, even that of the bed clothing. Most of my experience with this lesion was obtained in the French Army Hospitals in LeMans, with Delageniere, Tinel, and Jacquemin.

The fundamental lesion is thought by some to be an interneural and perineural sclerosis. The irritation thus set up in fibers at the site of injury to the nerves causes perverted afferent impulses to be sent back to the cord, and possibly to the subcortical and cortical centers. From here, efferent responses of vasodilator, secretory and trophic natures are reflected to the peripheral distribution of the nerve. In some cases it is necessary to resect the nerve and suture the ends. Following nerve suture, it is necessary to relax the tension as much as possible, and this is done by placing the limbs in various positions following the suture. In nerve suture, end-to-end anastomosis is the most likely method to succeed. The nerve ends must be treated very gently and it is important in suturing that the nerve is not rotated.

CAUSALGIC STATES AND NEUROTROPHIC LESIONS OF THE EXTREMITIES

There is a variety of names used to designate this syndrome such as minor causalgia, Sudeck's atrophy, posttraumatic osteoporosis, peripheral trophoneurosis, chronic traumatic edema, and posttraumatic dystrophy. These diagnoses according to DeTakats simply emphasize different manifestations of the same syndrome.

A sympathetic block with 1 per cent procaine injected into the area of the regional sympathetics will frequently abolish the throbbing and burning pain and allow mobility of the parts as far as the edema and fibrosis will permit. Under its protection, active and passive exercises may be started, but again too much heat and massage will aggravate the pain. Such blocks should be repeated when their effect wears off, which may be from days to weeks. If the patient responds favorably the duration of relief becomes longer and longer. The application of cold is a useful test.

VASCULAR AND NEUROLOGICAL LESIONS OF THE EXTREMITIES IN SURVIVORS OF SHIPWRECK

Painful and Swollen Feet Secondary to Prolonged Dehydration and Malnutrition.—Unlike the more severe thermal injuries suffered by the

survivor of vessels torpedoed in the North Atlantic, where vascular thrombosis and sepsis may necessitate amputation, the peripheral lesions in the southern cases according to White were not serious and required over a fortnight's hospitalization in only 6 cases Three of these were the West African negroes, who undoubtedly had complicating injuries from immersion in cold water and less evidence of a vitamin deficiency than their Anglo-Saxon crewmates In all the men the peripheral edema subsided promptly on bed rest, elevation of the legs, and an adequate diet The most incapacitating symptom was the neuritic pain in the feet This persisted for nearly two months in the three negroes, two of whom were not given special vitamin therapy The neuritic manifestations disappeared within a period of three to ten days after a high intake of vitamin B

FUNCTIONAL NEUROLOGICAL DISORDERS OF THE FOOT AND ANKLE

I shall limit my discussion to the neurologic meaning of this term rather than the disorders of function of the foot and ankle The functional disorders may be primary and secondary They are hysteria, exaggeration and malingering

The orthopædic surgeon is frequently confronted with functional neurological conditions The combination of a functional disturbance and a definite orthopædic condition is very common, and neither the neurologist, the psychiatrist, nor the orthopædic surgeon working alone can aid these patients The diagnosis is often difficult when hysteria is associated with an organic defect In the treatment it is often necessary to combine psychotherapy with physical therapy and orthopædic management Relief from an organic lesion will often cure a functional disorder Cure of the organic disorder does not necessarily give relief of the functional one but removes an important hurdle from the psychiatrist's path

Neurasthenia is a state characterized by abnormal fatigability and exaggerated irritability The neurasthenic shows both physical and mental exhaustion

Psychogenic Symptoms —While in the majority of cases pain is attributed to, and adequately accounted for, by obvious organic causes, in some, the severity of the pain and its persistence appear to be out of proportion to the organic lesion and in others no organic condition can be detected Bramwell emphasizes the importance of the character of the pain, its constancy and intensity and circumstances which appear to influence it, the cause to which the patient attributes his pain, the personality of the individual, his behavior, surroundings, suggestibility, and general outlook on his case, responsibilities, the existence of an inferiority complex, financial situation and the question of compensation

Pratt, Golden and Rosenthal obtained complete relief in 45 cases of psychalgia by the infiltration of the skin over the painful area with a 2 per cent procain solution. Hysterical conditions constitute one branch of functional lesions. Charcot recognized that hysterical arthropathies simulated very closely organic arthropathies. In civil practice most cases of functional disturbances of the joint occur in females. In military and industrial work, the opposite is true. Arthropathy is frequently the first manifestation of hysteria. Functional arthropathy often follows a slight trauma associated with emotional shock.

Hysterical anesthesias occasionally occur. Diminution of sensation is more common. These anesthesias are not limited to typical neural distributions, but involve a limb or part of a limb, "glove and stocking," half of the body and the mucous membranes.

The hysterical foot is one which is maintained in an unusual position, usually equino-varus, with no organic cause for the position. It should be treated by suggestion; support; retention in the proper position, by plaster-of-Paris if necessary; exercise; massage; contrast baths and in rare cases, by incision of the skin and suture.

PSYCHOSOMATIC PROBLEMS AFFECTING THE FOOT AND ANKLE IN MILITARY ORTHOPEDIC SURGERY*

World Wars I and II have given impetus to the study and understanding of the neuroses. Involvement of the musculoskeletal system by these disorders is more common in the Army than was formerly appreciated. Orthopaedic surgeons, as well as other clinical specialists, have come to the realization that there is a psychiatric aspect to their specialty which they can neither ignore nor deal with merely by intuition. Many have been so fascinated by the physical phase of the work that too little recognition has been given to psychosomatic problems—even to the extent of carrying out heroic operative procedures upon neurotic patients.

Three types of psychological problems have regularly appeared in the Orthopædic Section: (1) psychogenic problems in which no relevant organic lesion could be uncovered, either in the present or in the past; (2) psychogenic problems which were secondary to organic lesions; and (3) psychogenic problems which perpetuated some of the physical symptoms of a healed organic lesion. From a psychiatric standpoint, the cases with psychogenic musculoskeletal symptoms may be divided into those with (a) conversion reactions, (b) anxiety or tension states, and (c) elaborations (psychogenic elaboration of symp-

* Luck, J. Vernon. Jour. Bone and Joint Surg., April, 1946.

toms from an organic lesion) Various combinations of these three types are more common than pure types

Where there are concomitant functional and organic symptoms, every effort is made to determine the relative part each plays in the clinical picture, and therapy is directed toward each component The need for recognition of the emotional factors associated with organic diseases is well stated by Weiss and English "The day is near at hand for the final outmoding of the 'either-or' concept (either functional or organic) in diagnosis and to place in its stead the idea of how much of one and how much of the other, that is, how much of the problem is emotional and how much is physical"

1 There is a psychiatric aspect to orthopaedic surgery which should receive increased recognition

2 A psychosomatic diagnosis must be made on the basis of positive findings, and not alone by excluding organic entities

3 Psychogenic musculoskeletal symptoms were found in 11 1 per cent of the patients hospitalized in the Orthopaedic Section Among patients in the Orthopaedic Out-Patient Department the incidence of psychological disorders was over 25 per cent Approximately 1,000 patients with psychogenic musculoskeletal symptoms were studied

4 Based upon the relationship to organic symptoms three types of psychological problems were observed (1) those occurring without known relationship to an organic lesion, (2) those secondary to and accompanying an organic lesion, and (3) those perpetuating symptoms of a healed organic lesion Based upon psychiatric symptoms, the types seen were (1) conversion reactions, (2) anxiety states, and (3) psychogenic elaboration of organic symptoms

5 An abbreviated psychological history was obtained from all patients in whom the source of symptoms was obscure and the objective findings were bizarre

6 Musculoskeletal pains of uncertain origin should be analyzed in terms of their exact character Neurotic pains frequently include a sense of pressure, tension, or numbness Bizarre radiating pains, particularly those radiating from a distal point proximally, are often psychogenic Psychogenic and organic musculoskeletal symptoms are compared

7 There may be several objective findings to identify a neurosis, or there may be none The findings most often encountered include circumferential hypalgesia, hysterical paralysis, coarse intention tremors, and anxiety symptoms

8 In 100 consecutive cases in which conversion reactions included circumferential hypalgesia, the patterns of hypalgesia are presented Ten of the 100 patients had hysterical paralysis

9 Sites of neurotic musculoskeletal symptoms follow a pattern

Pratt, Golden and Rosenthal obtained complete relief in 15 cases of psychalgia by the infiltration of the skin over the painful area with a 2 per cent procain solution. Hysterical conditions constitute one branch of functional lesions. Charcot recognized that hysterical arthropathies simulated very closely organic arthropathies. In civil practice most cases of functional disturbances of the joint occur in females. In military and industrial work, the opposite is true. Arthropathy is frequently the first manifestation of hysteria. Functional arthropathy often follows a slight trauma associated with emotional shock.

Hysterical anesthesias occasionally occur. Diminution of sensation is more common. These anesthesias are not limited to typical neural distributions, but involve a limb or part of a limb, "glove and stocking," half of the body and the mucous membranes.

The hysterical foot is one which is maintained in an unusual position, usually equino-varus, with no organic cause for the position. It should be treated by suggestion; support; retention in the proper position, by plaster-of-Paris if necessary; exercise; massage; contrast baths and in rare cases, by incision of the skin and suture.

PSYCHOSOMATIC PROBLEMS AFFECTING THE FOOT AND ANKLE IN MILITARY ORTHOPEDIC SURGERY*

World Wars I and II have given impetus to the study and understanding of the neuroses. Involvement of the musculoskeletal system by these disorders is more common in the Army than was formerly appreciated. Orthopaedic surgeons, as well as other clinical specialists, have come to the realization that there is a psychiatric aspect to their specialty which they can neither ignore nor deal with merely by intuition. Many have been so fascinated by the physical phase of the work that too little recognition has been given to psychosomatic problems—even to the extent of carrying out heroic operative procedures upon neurotic patients.

Three types of psychological problems have regularly appeared in the Orthopædic Section: (1) psychogenic problems in which no relevant organic lesion could be uncovered, either in the present or in the past; (2) psychogenic problems which were secondary to organic lesions; and (3) psychogenic problems which perpetuated some of the physical symptoms of a healed organic lesion. From a psychiatric standpoint, the cases with psychogenic musculoskeletal symptoms may be divided into those with (a) conversion reactions, (b) anxiety or tension states, and (c) elaborations (psychogenic elaboration of symp-

* Luck, J. Vernon, Jour. Bone and Joint Surg., April, 1946

toms from an organic lesion) Various combinations of these three types are more common than pure types

Where there are concomitant functional and organic symptoms, every effort is made to determine the relative part each plays in the clinical picture, and therapy is directed toward each component. The need for recognition of the emotional factors associated with organic diseases is well stated by Weiss and English "The day is near at hand for the final outmoding of the 'either-or' concept (either functional or organic) in diagnosis and to place in its stead the idea of how much of one and how much of the other, that is, how much of the problem is emotional and how much is physical"

1 There is a psychiatric aspect to orthopedic surgery which should receive increased recognition

2 A psychosomatic diagnosis must be made on the basis of positive findings, and not alone by excluding organic entities

3 Psychogenic musculoskeletal symptoms were found in 11 1 per cent of the patients hospitalized in the Orthopaedic Section Among patients in the Orthopaedic Out-Patient Department, the incidence of psychological disorders was over 25 per cent Approximately 1,000 patients with psychogenic musculoskeletal symptoms were studied

4 Based upon the relationship to organic symptoms, three types of psychological problems were observed (1) those occurring without known relationship to an organic lesion, (2) those secondary to and accompanying an organic lesion, and (3) those perpetuating symptoms of a healed organic lesion Based upon psychiatric symptoms, the types seen were (1) conversion reactions, (2) anxiety states, and (3) psychogenic elaboration of organic symptoms

5 An abbreviated psychological history was obtained from all patients in whom the source of symptoms was obscure and the objective findings were bizarre

6 Musculoskeletal pains of uncertain origin should be analyzed in terms of their exact character Neurotic pains frequently include a sense of pressure, tension, or numbness Bizarre radiating pains, particularly those radiating from a distal point proximally, are often psychogenic Psychogenic and organic musculoskeletal symptoms are compared

7 There may be several objective findings to identify a neurosis, or there may be none The findings most often encountered include circumferential hypalgesia, hysterical paralysis, coarse intention tremors, and anxiety symptoms

8 In 100 consecutive cases in which conversion reactions included circumferential hypalgesia, the patterns of hypalgesia are presented Ten of the 100 patients had hysterical paralysis

9 Sites of neurotic musculoskeletal symptoms follow a pattern

Pratt, Golden and Rosenthal obtained complete relief in 45 cases of psychalgia by the infiltration of the skin over the painful area with a 2 per cent procain solution. Hysterical conditions constitute one branch of functional lesions. Charcot recognized that hysterical arthropathies simulated very closely organic arthropathies. In civil practice most cases of functional disturbances of the joint occur in females. In military and industrial work, the opposite is true. Arthropathy is frequently the first manifestation of hysteria. Functional arthropathy often follows a slight trauma associated with emotional shock.

Hysterical anesthesias occasionally occur. Diminution of sensation is more common. These anesthesias are not limited to typical neural distributions, but involve a limb or part of a limb, "glove and stocking," half of the body and the mucous membranes.

The hysterical foot is one which is maintained in an unusual position, usually equino-varus, with no organic cause for the position. It should be treated by suggestion; support; retention in the proper position, by plaster-of-Paris if necessary; exercise; massage; contrast baths and in rare cases, by incision of the skin and suture.

PSYCHOSOMATIC PROBLEMS AFFECTING THE FOOT AND ANKLE IN MILITARY ORTHOPEDIC SURGERY*

World Wars I and II have given impetus to the study and understanding of the neuroses. Involvement of the musculoskeletal system by these disorders is more common in the Army than was formerly appreciated. Orthopaedic surgeons, as well as other clinical specialists, have come to the realization that there is a psychiatric aspect to their specialty which they can neither ignore nor deal with merely by intuition. Many have been so fascinated by the physical phase of the work that too little recognition has been given to psychosomatic problems—even to the extent of carrying out heroic operative procedures upon neurotic patients.

Three types of psychological problems have regularly appeared in the Orthopædic Section: (1) psychogenic problems in which no relevant organic lesion could be uncovered, either in the present or in the past; (2) psychogenic problems which were secondary to organic lesions; and (3) psychogenic problems which perpetuated some of the physical symptoms of a healed organic lesion. From a psychiatric standpoint, the cases with psychogenic musculoskeletal symptoms may be divided into those with (a) conversion reactions, (b) anxiety or tension states, and (c) elaborations (psychogenic elaboration of symp-

* Luck, J. Vernon. Jour Bone and Joint Surg., April, 1946.

toms from an organic lesion) Various combinations of these three types are more common than pure types

Where there are concomitant functional and organic symptoms, every effort is made to determine the relative part each plays in the clinical picture, and therapy is directed toward each component The need for recognition of the emotional factors associated with organic diseases is well stated by Weiss and English "The day is near at hand for the final outmoding of the 'either-or' concept (either functional or organic) in diagnosis and to place in its stead the idea of how much of one and how much of the other, that is, how much of the problem is emotional and how much is physical"

1 There is a psychiatric aspect to orthopædic surgery which should receive increased recognition

2 A psychosomatic diagnosis must be made on the basis of positive findings, and not alone by excluding organic entities

3 Psychogenic musculoskeletal symptoms were found in 11 1 per cent of the patients hospitalized in the Orthopedic Section Among patients in the Orthopædic Out-Patient Department, the incidence of psychological disorders was over 25 per cent Approximately 1,000 patients with psychogenic musculoskeletal symptoms were studied

4 Based upon the relationship to organic symptoms, three types of psychological problems were observed (1) those occurring without known relationship to an organic lesion, (2) those secondary to and accompanying an organic lesion, and (3) those perpetuating symptoms of a healed organic lesion Based upon psychiatric symptoms, the types seen were (1) conversion reactions, (2) anxiety states, and (3) psychogenic elaboration of organic symptoms

5 An abbreviated psychological history was obtained from all patients in whom the source of symptoms was obscure and the objective findings were bizarre

6 Musculoskeletal pains of uncertain origin should be analyzed in terms of their exact character Neurotic pains frequently include a sense of pressure, tension, or numbness Bizarre radiating pains, particularly those radiating from a distal point proximally, are often psychogenic Psychogenic and organic musculoskeletal symptoms are compared

7 There may be several objective findings to identify a neurosis, or there may be none The findings most often encountered include circumferential hypalgesia, hysterical paralysis, coarse intention tremors, and anxiety symptoms

8 In 100 consecutive cases in which conversion reactions included circumferential hypalgesia, the patterns of hypalgesia are presented Ten of the 100 patients had hysterical paralysis

9 Sites of neurotic musculoskeletal symptoms follow a pattern

Pratt, Golden and Rosenthal obtained complete relief in 45 cases of psychalgia by the infiltration of the skin over the painful area with a 2 per cent procain solution. Hysterical conditions constitute one branch of functional lesions. Charcot recognized that hysterical arthropathies simulated very closely organic arthropathies. In civil practice most cases of functional disturbances of the joint occur in females. In military and industrial work, the opposite is true. Arthropathy is frequently the first manifestation of hysteria. Functional arthropathy often follows a slight trauma associated with emotional shock.

Hysterical anesthesias occasionally occur. Diminution of sensation is more common. These anesthesias are not limited to typical neural distributions, but involve a limb or part of a limb, "glove and stocking," half of the body and the mucous membranes

The hysterical foot is one which is maintained in an unusual position, usually equino-varus, with no organic cause for the position. It should be treated by suggestion; support; retention in the proper position, by plaster-of-Paris if necessary; exercise; massage; contrast baths and in rare cases, by incision of the skin and suture.

PSYCHOSOMATIC PROBLEMS AFFECTING THE FOOT AND ANKLE IN MILITARY ORTHOPEDIC SURGERY*

World Wars I and II have given impetus to the study and understanding of the neuroses. Involvement of the musculoskeletal system by these disorders is more common in the Army than was formerly appreciated. Orthopaedic surgeons, as well as other clinical specialists, have come to the realization that there is a psychiatric aspect to their specialty which they can neither ignore nor deal with merely by intuition. Many have been so fascinated by the physical phase of the work that too little recognition has been given to psychosomatic problems—even to the extent of carrying out heroic operative procedures upon neurotic patients.

Three types of psychological problems have regularly appeared in the Orthopædic Section: (1) psychogenic problems in which no relevant organic lesion could be uncovered, either in the present or in the past; (2) psychogenic problems which were secondary to organic lesions; and (3) psychogenic problems which perpetuated some of the physical symptoms of a healed organic lesion. From a psychiatric standpoint, the cases with psychogenic musculoskeletal symptoms may be divided into those with (a) conversion reactions, (b) anxiety or tension states, and (c) elaborations (psychogenic elaboration of symp-

* Luck, J. Vernon, Jour Bone and Joint Surg., April, 1946

toms from an organic lesion) Various combinations of these three types are more common than pure types

Where there are concomitant functional and organic symptoms, every effort is made to determine the relative part each plays in the clinical picture, and therapy is directed toward each component The need for recognition of the emotional factors associated with organic diseases is well stated by Weiss and English "The day is near at hand for the final outmoding of the 'either-or' concept (either functional or organic) in diagnosis and to place in its stead the idea of how much of one and how much of the other, that is, how much of the problem is emotional and how much is physical"

1 There is a psychiatric aspect to orthopaedic surgery which should receive increased recognition

2 A psychosomatic diagnosis must be made on the basis of positive findings, and not alone by excluding organic entities

3 Psychogenic musculoskeletal symptoms were found in 11 1 per cent of the patients hospitalized in the Orthopaedic Section Among patients in the Orthopaedic Out-Patient Department, the incidence of psychological disorders was over 25 per cent Approximately 1,000 patients with psychogenic musculoskeletal symptoms were studied

4 Based upon the relationship to organic symptoms, three types of psychological problems were observed (1) those occurring without known relationship to an organic lesion, (2) those secondary to and accompanying an organic lesion, and (3) those perpetuating symptoms of a healed organic lesion Based upon psychiatric symptoms, the types seen were (1) conversion reactions, (2) anxiety states, and (3) psychogenic elaboration of organic symptoms

5 An abbreviated psychological history was obtained from all patients in whom the source of symptoms was obscure and the objective findings were bizarre

6 Musculoskeletal pains of uncertain origin should be analyzed in terms of their exact character Neurotic pains frequently include a sense of pressure, tension, or numbness Bizarre radiating pains, particularly those radiating from a distal point proximally, are often psychogenic Psychogenic and organic musculoskeletal symptoms are compared

7 There may be several objective findings to identify a neurosis, or there may be none The findings most often encountered include circumferential hypalgesia, hysterical paralysis, coarse intention tremors, and anxiety symptoms

8 In 100 consecutive cases in which conversion reactions included circumferential hypalgesia, the patterns of hypalgesia are presented Ten of the 100 patients had hysterical paralysis

9 Sites of neurotic musculoskeletal symptoms follow a pattern

CHAPTER XXV

ANTERIOR POLIOMYELITIS—INFANTILE PARALYSIS

INFANTILE paralysis, acute anterior poliomyelitis or poliomyelo-encephalitis occurs most frequently in children between two and eighteen years of age.

The close interrelationship between the gluteal muscles, the quadriceps, the hamstrings, and the calf group, makes it desirable that the entire extremity be considered as one motor and locomotor mechanism, the various parts of which cannot reasonably be considered individually.

The symptoms are given in order to indicate early treatment and to take such action as will prevent deformity and disability. Complete muscle examination of the lower extremity is given. Immediate care includes support in bed, bed posture, braces, splints and plaster-of-Paris. Care during the chronic stage is given; care during rehabilitation; braces and support; operations; and post-operative care.

If only faradic current irritability is lessened, recovery can be predicted. The muscle which no longer reacts to faradism may still be made to contract by galvanism. While the upper part of the leg shows more involvement than the lower part, the total paralysis of the upper part is slight as compared with that of the lower part. The quadriceps is frequently affected. The leg muscles most severely paralyzed are the anterior and posterior tibials.

Differential Diagnosis.—Other acute infections accompanied by meningeal symptoms may simulate early or preparalytic poliomyelitis. Acute rheumatic fever, articular involvement from serum sickness, acute epiphysitis, scurvy, acute osteomyelitis, and acute suppurative joint affections may confuse the diagnosis.

In 1944, there were about 19,000 cases of poliomyelitis in the entire United States, the largest number ever recorded in any one year since 1916. In 1944, there were about 50,000,000 children under twenty years of age, living in this country.

These figures indicate to Basil O'Connor that for someone under twenty there is less than one chance in 2,500 of getting poliomyelitis, even in a polio year.

During 1942, over the entire United States there were 561 deaths from poliomyelitis, reported.

In 1942, about 1 victim of poliomyelitis in 7 died. People seem to become almost hysterical about poliomyelitis when they ought to realize that even in a bad year the chances of being struck down by it are comparatively slight and not nearly as great as the danger from automobile accidents and several common diseases.

Levinson and Milzer have succeeded in reproducing polio in white mice by the injection of virus taken from the feces of humans and treated by autolyzed brain tissue.

In partial paralysis, deformity may develop from the effects of gravity and unopposed muscle pull which will result in stretching of the paralyzed muscle and shortening of the tendons of the stronger muscles unless preventive measures are instituted The presence of deformities interferes seriously with the return of muscle power and function The importance of preventing deformities and the necessity of correcting them early is becoming more fully appreciated

Todd believes that if the patient has only one good buttock he can still be made to walk Conversely walking is rendered permanently impossible when the muscles of both buttocks are completely paralyzed and the legs are practically "disconnected" from the trunk

NON-OPERATIVE TREATMENT OF ANTERIOR POLIOMYELITIS

As soon as acute anterior poliomyelitis is suspected, the pediatrician or internist on the case should summon an orthopedic surgeon because orthopedic treatment should be begun as soon as the diagnosis is made

Nursing Care —The patient must be kept in bed with absolute physical and mental quiet The bed should be low and the mattress firm Boards or a wooden frame may be placed under one or two mattresses An illuminated cradle should be used to keep the coverings off the feet, and the limbs warm Deformity is preventable Rest is essential The muscles must be protected from stretching and fatigue A major consideration is protection of the muscles Under no circumstances should massage exercise, or electrical stimulation be used during the acute stage Chiropractic and osteopathic treatments may do irreparable harm

Splinting —The first consideration is to place the joints in position of balance or neutral muscle pull so that no muscle will be overstretched as compared with its opponents A contracted muscle can usually be stretched with safety, but the tone and elasticity of a stretched muscle cannot be easily restored The correct positions are easily maintained by means of pillows, folded blankets, bandages and bags salt bags, covered bricks, splints, and casts The optimum positions are as follows

- Foot At a right angle with no inversion or eversion
- Knee In 5 to 10 degrees of flexion with no varus or valgus
- Hip In from 15 to 20 degrees of abduction with no flexion or rotation
- Back Flat or slightly elevated in the thoracic region with a small pad under the lumbar spine
- Abdomen Should not be allowed to become pendulous

The Kenny Method of Treatment in the Acute Stage —Sister Kenny, of Australia, advocates the following treatment In the acute sensitive stage, hot applications are applied Wool, such as found in army

blankets, is ideal. It should be practically boiled, in a boiler, then fished out by means of a pole or forceps. Then it should be forced through a tight wringer twice. It will then be almost dry and will not burn the skin. The new Emerson apparatus is very convenient. These are applied from one joint to another, but not over the joint, in order to permit passive and active movements. These dressings are protected with oiled silk and more dry warm wool, and are changed every half hour during the first twenty-four to forty-eight hours. This is continued twenty-four hours a day.

After the extremely sensitive period has passed, the procedure is carried out from 8 A.M. to 8 P.M. and then only every two hours. The fomentations gradually cool. A small roll of towel material is used under the knees. The "proprioceptive nerve center" area is never allowed to be covered during the night, as long as there is spasm in the muscles.

Gentle passive exercises are given, but never to the point of pain. These are carried out during the first two days of the sensitive stage. The patient's activities are directed and concentrated in the area of the tendon where movement is to be expected. The operator passes her fingers along the course of the tendons and insertions of the muscles. After two passive movements, one active movement is attempted.

The most important practical benefits derived from this treatment are evidently rapid relief from pain and sensitiveness and the prevention of contractures.

Miss Kenny's theory of the situation in acute poliomyelitis is based upon:

I. Muscle spasm.
II. Incoördination.
  Due to pain.
  Due to substitution of muscle function.
III. Mental alienation.
  The patient forgets to perform normal muscle function.
  He loses the idea of making muscles contract.

Her procedure in correcting the situation is:

I. No splints of any kind except the foot board and the inherent splinting that is in the fomentations.
II. Hot fomentations.
  Very hot—to relax spasm—every one-half to two hours from 8 A.M. to 8 P.M.
III. Special muscle reëducation.
  Concentrating on insertions of muscles.
IV. Avoidance of fatigue.
V. Maintenance of proper positions.
VI. Complete joint motion (possible because of less pain and no contractures).

Treatment by Warm Sea-salt Baths.—Warm sea-salt baths relieve muscle and nerve pains. In some cases they may be begun within seven

days after the onset of the disease. Several handfuls of sea salt are dissolved in a tub two-thirds full of water at a temperature of about 94° F. The patient should wear a rubber cap. He should be carried to the tub on a stretcher or in a sheet. The duration of the bath should be from five to fifteen minutes. The analgesic effect is striking.

Hubbard devised an excellent tub which can be used after the disappearance of acute pain and sensitiveness, possibly at the end of the seventh or the fourteenth day. I designed a unit which has proved satisfactory. (Another efficient tub has been designed by Currence.)

Treatment During the Convalescent Stage.—The convalescent stage begins when tenderness ceases. Treatment by rest and the maintenance of correct positions should continue. The skin and muscles should be kept warm. Warm sea-salt baths are helpful because they increase the circulation and prepare the patient for exercises.

Diathermy, inductotherm, roentgen treatment, electrical stimulation, massage, and graded exercises or neuro-muscular reeducation are additional aids.

Diathermy.—It is believed by some writers that diathermy hastens the subsidence of the edema in the involved areas, exerts a bactericidal influence, and increases the circulation.

Roentgenotherapy.—Improvement has been reported following roentgen irradiation in hyperesthetic patients and in patients during the chronic phase.

Electrical Therapy.—The sinusoidal current applied over the motor points of the muscles before active power has returned, maintains tone and circulation and prevents adhesions.

Considerable research work is in progress with the hope that denervated muscles can be stimulated to contract.

Massage.—Light massage given by an expert masseur is valuable.

Muscle Diagnosis and Training.—Before appropriate exercises can be prescribed each muscle must be graded as to its power.

Lowman's grading is preferable for group and statistical analysis, Plastridge's, for progress of the individual patient.

MUSCLE CHART

Name	Date		Age
Cannot walk	Walks unaided	With braces	Corset
Characteristic gait			
Left	*Contractures and Deformities*		*Right*
	Hip		
	Knee		
	Ankle		
	Legs		
	Measurements		
	Length		
	Calf		
	Thigh		

Lower Extremities

Left		*Right*
	Gluteus maximus	
	Iliopsoas	
	Sartorius	
	Tensor fasciæ latæ	
	Hip abductors	
	Hip adductors	
	Hip outward rotators	
	Hip inward rotators	
	Quadriceps	
Inner	Hamstrings	Inner
Outer		Outer
	Gastrocnemius	
	Anterior tibial	
	Posterior tibial	
	Peroneus longus	
	Peroneus brevis	
	Extensor longus digitorum	
	Extensor brevis digitorum	
	Extensor proprius hallucis	
	Flexor longus digitorum	
	Flexor brevis digitorum	
	Flexor lumbricales	
	Flexor longus hallucis	
	Flexor brevis hallucis	

Several schemes have been proposed for the evaluation of muscle power. A satisfactory scheme is the following:

1. Normal:
2. Good: a muscle that can overcome gravity and some resistance, but cannot perform the normal test.
3. Fair: A muscle that can overcome gravity, but not resistance.
4. Poor: A muscle that can carry out its action when gravity is eliminated.
5. Trace: A muscle which can be felt to contract, but cannot move the part.
6. Gone: A muscle in which no contraction can be felt.

Tests for Muscles of the Extremities

Plastridge's Tests.—All tests are made against as much resistance as the muscle can overcome.

Examination of the Lower Extremity.—A. *Patient Sitting on the Edge of a Table.*—(If the examination is made during or immediately following the acute period, or if the back or abdominal muscles are seriously involved, these tests should be made with the patient in the lying position.)

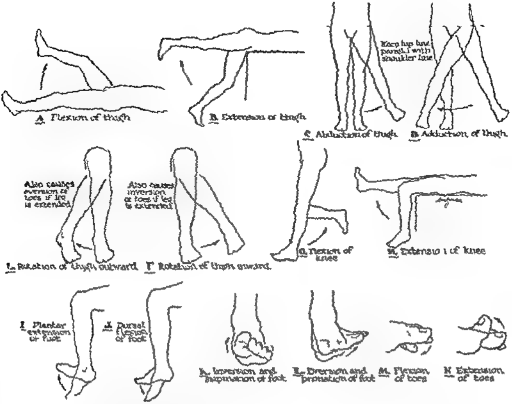


FIG 282 —*Muscle functions of the lower extremities* Examination of motor functions In *C* and *D* abduction and adduction of thigh the line between the hip joints must be kept parallel to the line between the shoulders to prevent movement of the spine compensating for poor movement at the hip joint (Redrawn from pamphlet distributed by Am Med Assn at Milwaukee 1933)

1 Toe Flexors Keep the foot at a right angle and curl the toes down Examine the phalanges separately to determine the strength of the long and short flexors as well as the flexors of the proximal phalanges

2 Toe Extensors With the foot at a right angle, raise the toes The long extensors of the big toe (extensor hallucis proprius) and of the four small toes (extensor digitorum brevis) can be felt in front of the outer malleolus

3 Tibialis Anticus (dorsal flexor) With the toes relaxed and the foot slightly supinated, raise the foot (Feel for tendon action on the inner side of the dorsal aspect of the foot)

4 Tibialis Posticus (inversion or adduction) With the toes relaxed, turn the foot inward without supination (Feel for the tendon below the inner malleolus)

5 Peronei Longus and Brevis (eversion) With the toes relaxed, turn the foot outward (Feel for the tendon over or below the outer malleolus)

6. Gastrocnemius (plantar flexor). With the toes relaxed, push the foot downward by pulling the heel backward. Action can be felt at the back of the heel or in the muscle fibers above.
7. Quadriceps Femoris (knee extensor). Raise the lower leg to straighten the knee. Tendon action can be felt below the patella, or muscle action on the anterior surface of the thigh.
8. Iliopsoas (hip flexor). Keeping the knee bent, raise the thigh from the table as high as possible without allowing the body to lean backward. The tendon is sometimes felt through the abdominal wall or deep in the groin. The occurrence of external rotation on hip flexion denotes iliopsoas weakness.
9. Sartorius (hip flexor). Bend the knee against resistance applied at the ankle while slightly raising the thigh from the table. (Feel for the tendon just below the anterior superior spine of the ilium.)
10. Tensor Fasciæ Latæ (hip flexor and abductor). Keeping the knee extended, raise the leg from the table. Tendon action is felt in the iliotibial band at the outer side of the knee and along the anterior crest of the ilium.
11. Inward Rotators of Hip. Keeping the knee flexed and the knees together, push the lower leg outward. (Push the feet apart.)
12. Outward Rotators of Hip. With the same starting position as for inward rotation, push the lower leg inward, crossing it behind the other leg.

B. *Patient Lying on Back.* Adductors of hip (opposite leg). The examiner holds the upper leg high in the air. The patient raises the under leg up to it, keeping the knee straight. Muscle action is felt along the inner portion of the thigh.

D. *Patient Lying Face Down.*

1. Gluteus Maximus (hip extensor). Raise the entire leg from the table. Muscle action occurs in the buttock.
2. Hamstrings, Inner and Outer (knee flexors). Bend the knee. (Feel tendons just above the knee.)

Muscle Training.—When an accurate muscle diagnosis has been made, active muscle training is begun with exercise for five or ten minutes once a day, as soon as all soreness of the limbs has disappeared.

It is important that the child be placed in the hands of a person who understands both the theory and the technic of muscle training.

In an affected limb, some of the muscles are paralyzed, some are weakened, and some are comparatively normal. If not expertly controlled, the patient will naturally use and develop the strong muscles.

thus increasing muscular imbalance, which leads to deformity Over-use or improper use of an affected limb is probably worse than disuse

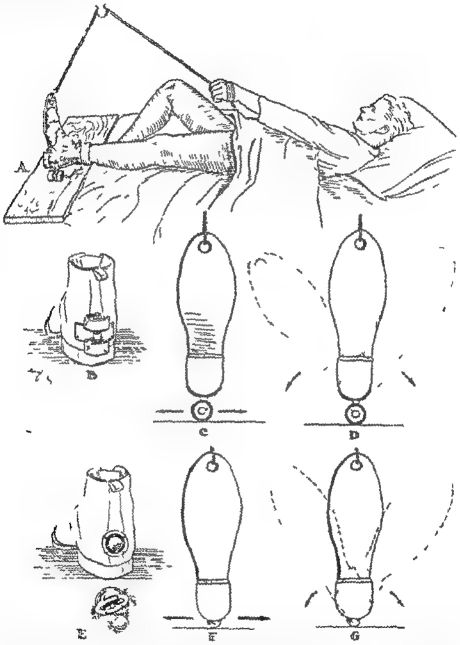


FIG 283 —Roller skate attached to shoe Rachlin places the patient on his side and attaches a roller skate on the inner side of the upper leg so that the thigh can be swung back and forth in the horizontal plane gravity and the retarding effect of the bed clothes being thus overcome *By adjusting the skate to other parts of the limb in the* line of muscle pull the same effect can be achieved elsewhere as for quadriceps and hamstring action on the inner aspect of the foot *E F* and *G* illustrate Gaenslen s ball bearing shoe

Muscle training consists in aiding the patient to perform a certain movement The patient is told to contract a muscle The limb is

placed in such a position that gravity will impel performance of the movement, or the movement is assisted by hand.

If a brace is used, it should be light in weight and allow as much joint freedom as is possible without causing deformity. A brace means the upright position, and the upright position means more muscular activity. According to Lovett, the best way to avoid wearing a brace permanently, is to "put it on early and keep it on as long as necessary."

(The reader is referred to two books, "Muscle Function," by Wilhelmine G. Wright [Paul B. Hoeber, Inc., New York City, 1928], and "The Mechanics of Normal and Pathological Locomotion in Man," by Arthur Steindler [Charles C Thomas, Springfield, Ill., 1935]).

For the elimination of friction in the muscles of the lower extremity, Gaenslen and Blount devised a ball-bearing shoe. They fasten into the counter portion of the heel of the shoe, exactly in the mid-line, a steel ball-bearing $\frac{3}{4}$ inch in diameter. The entire vamp of the shoe is removed and a hole made in the sole about 1.2 inches from the middle of the toe section. Through this hole one end of a thin rope is passed and fastened. The other end, which is controlled by the patient, is passed over a pulley secured to an overhead suspension on the bed. Gentle pulling on the rope suspends the foot on the ball-bearing which rests on a smooth board. By this means of eliminating all friction and weight of the foot, the muscles of the leg are enabled to perform movements which they could not execute without it. The leg is moved in abduction, adduction, flexion, and extension, and combinations of these movements. Gaenslen and Blount also recommend suspending the extremities to be exercised in a sling to eliminate gravity and friction.

Smart says that the graduated muscular contraction method (electrical stimulation) is of benefit mainly because it keeps neighboring unparalyzed muscles in activity during the acute stages of the paralysis. When muscles that have been paralyzed show signs of recovery, graduated contractions hasten recovery. In cases of old poliomyelitis in which the muscles show various degrees of recovery, long-continued stimulation by graduated exercises frequently yields remarkable results, particularly when the muscles have regained fair voluntary power. They can then be overdeveloped. Such increases of power greatly improve the general function and control of the limb.

Underwater Gymnastics.—Lowman allows the patient to begin underwater movements as early as the twenty-first day, and to walk in deep water at the end of four or five weeks. The patient is submerged up to his neck. This treatment improves his morale by eliminating pain fear and anxiety and giving him pleasure. It restores balance and instills courage. The general health, sleep, and appetite improve. Nervousness diminishes. The buoyancy of the water minimizes

fatigue of the weakened muscles Ability to swim is a most valuable asset Swimming should be a part of the school drill It is a sport in which the crippled child can equal others However, Lowman warns against unsupervised swimming He calls the treatment pool a "hydrogymnasium" He deplores the attempt to popularize swimming treatment, made by swimming teachers and technicians who have not been trained for the work of muscular reeducation Normal muscles or muscles stronger than their opponents are the ones by

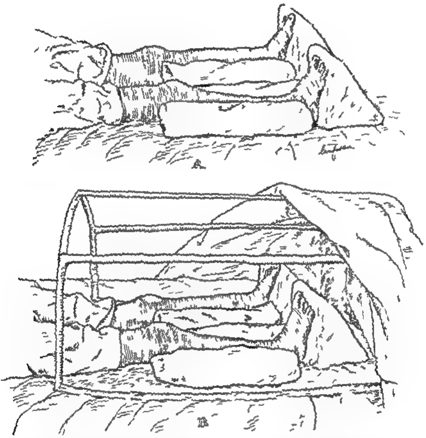


Fig 284 — A Position of legs ankles and feet in cases of poliomyelitis showing the maintenance of position of neutral muscle pull by means of sandbags and foot supports *B* Cradle in position to keep bed clothes off the extremities (Drawn from photographs in Am Med Assn Booklet on Poliomyelitis)

which progression through water is achieved In ordinary swimming, such muscles become still stronger than their opponents and thereby produce deformities Ordinary pools are too cold for poliomyelitic patients Heating the muscles before exercising is helpful For ordinary hypotonic cases, a temperature of 90° F is satisfactory Hot water is debilitating

Lowman finds that a wooden slab with a foot-board, fitted with iron hooks, which is suspended from the side of the hydrogymnastic tank is valuable in removing fear as it keeps the body from slipping into deep

water during the exercises. Waterwings and overwater rings are helpful. Some swimming tanks have been outfitted with pulleys and ropes by which patients are suspended in the water. The combination of movements in the water tank and muscle reëducation exercises on the table is ideal.

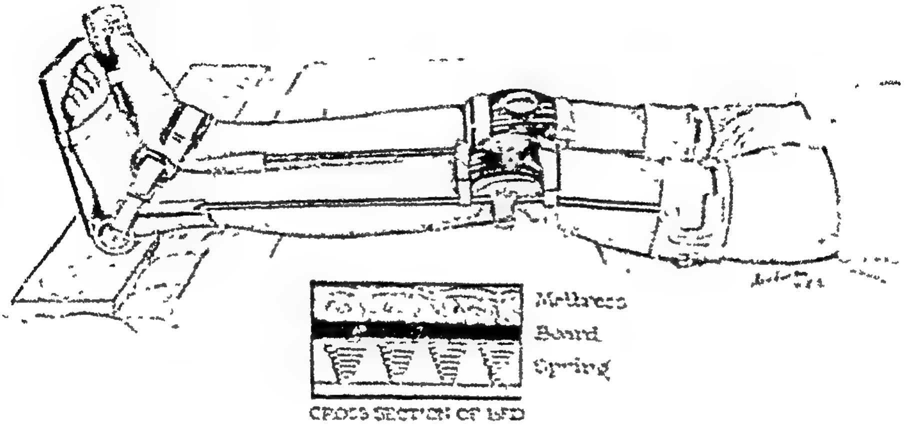


FIG. 285.—First aid or preliminary copper wire splint for prevention of deformities of foot, ankle and leg in poliomyelitis. Lower figure illustrates the "rigid mattress" made by inserting board underneath. (Redrawn from Legg and Merrill, Principles and Practice of Physical Therapy, courtesy of W. F. Prior Company.)

Pope Tank.—Margaret Pope performed her exercises more successfully while in a cypress tank 4½ feet high and 6 feet in diameter. It had a brass rail around the inside near the top. The temperature of

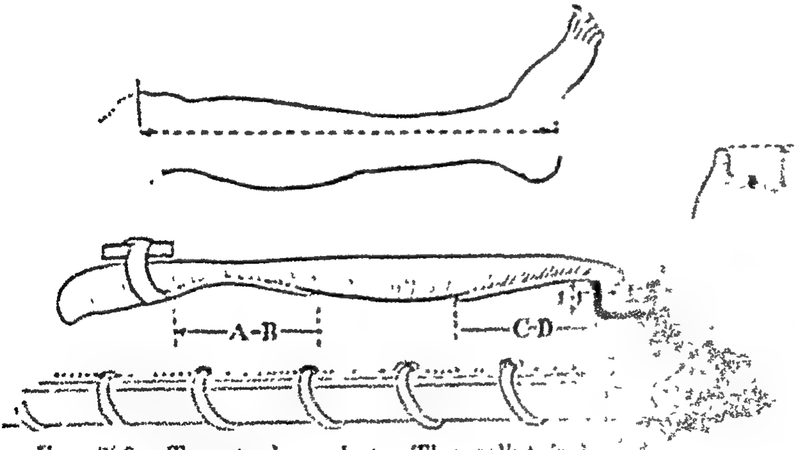


FIG. 286.—Toronto leg splint. This splint is ... flexed and the foot at a right angle. If it is desired ... frame should be used and no pillows allowed under ... the bottom of the splint is intended to prevent rotatio... If no Bradford frame is used, a board may be placed un... courtesy of Jour. Bone and Joint Surg. and Marylan... Baltimore.)

the water should be between 88° and ... water in which 2 tablespoo... is poured into the tank ... from becoming slimy...

Warm Springs, Georgia —The institution at Warm Springs, Georgia, for patients convalescing from poliomyelitis is situated on Pine Mountain, 76 miles southwest of Atlanta, elevation about 1,200 feet The late President Franklin D Roosevelt, himself a victim of poliomyelitis, aided in its building It has two swimming pools and two exercise pools which are fed from natural warm springs with water at a constant temperature of 89° F The enclosed pool is 85 feet long, 35 feet wide, and 14 feet, 8 inches deep The outside pool is 69 feet long, 35 feet

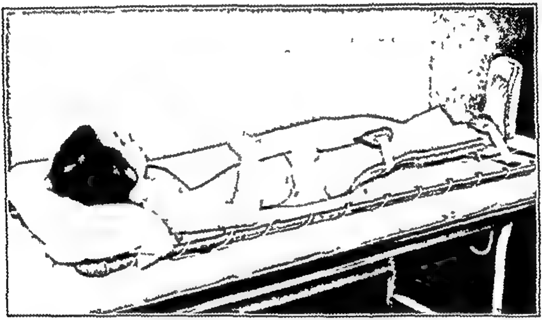


FIG 257 – Toronto leg splint applied to patient on Bradford frame The splint is padded fairly heavily and should require no further padding The edges of the splint can be bent out if necessary by strong finger pressure The strap around the thigh should be 1 or 2 inches above the patella and can be fixed at the proper level by the dome fasteners The strap over the instep should be tight enough to hold the sole of the heel against the foot piece and to prevent any drop foot deformity No cradle is necessary as the foot piece is long enough to keep the bed clothes from pressing on the toes A stocking may be worn under the straps of the splint The whole leg should always be kept warm by sufficient bed coverings The splint should be worn constantly but should be removed once a day for the necessary inspection and care of the skin (Courtesy of Le Mesurier Jour Bone and Joint Surg and the Maryland League for Crippled Children Baltimore Md)

wide, and 3 feet 8 inches deep *In teaching a patient to walk, emphasis* is placed on coordination and balance These powers are restored more quickly by treatment under water than by other treatment Before or after the exercises in the water, depending on the patient's reaction, sun baths modified to the tolerance of the patient, are given The morning is taken up with exercises, swimming, and sun baths Lunch is followed first by three hours of rest and then by walking exercises Ramps and handrails are used to teach the patient balance and coordination in walking

water during the exercises. Waterwings and overwater rings are helpful. Some swimming tanks have been outfitted with pulleys and ropes by which patients are suspended in the water. The combination of movements in the water tank and muscle reëducation exercises on the table is ideal.

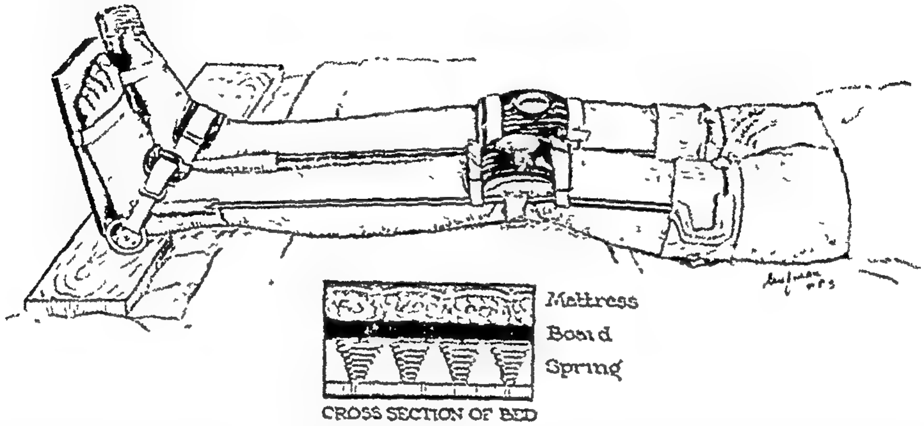


FIG. 285.—First aid or preliminary copper wire splint for prevention of deformities of foot, ankle and leg in poliomyelitis. Lower figure illustrates the "rigid mattress" made by inserting board underneath. (Redrawn from Legg and Merrill, Principles and Practice of Physical Therapy, courtesy of W. F. Prior Company.)

Pope Tank.—Margaret Pope performed her exercises more successfully while in a cypress tank 4½ feet high and 6 feet in diameter. It had a brass rail around the inside near the top. The temperature of

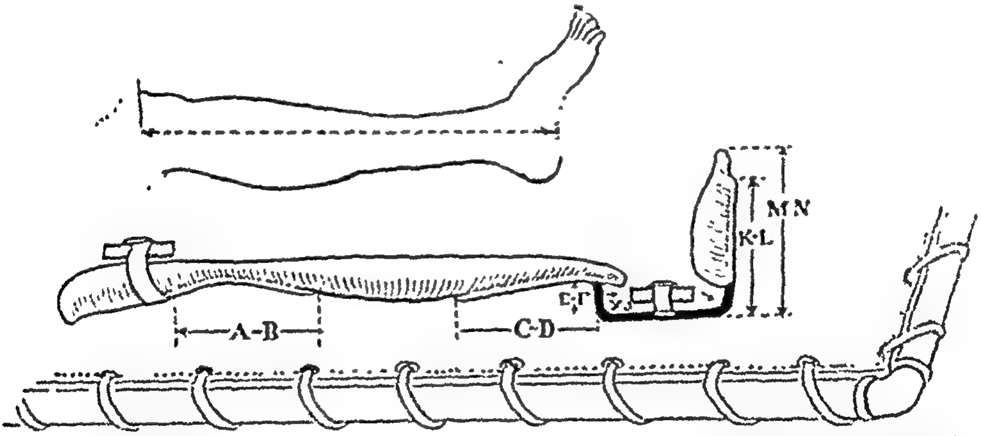


FIG. 286.—Toronto leg splint. This splint is intended to hold the knee slightly flexed and the foot at a right angle. If it is desired to hold the hip extended, a Bradford frame should be used and no pillows allowed under the shoulders. The cross-bar at the bottom of the splint is intended to prevent rotation of the limb in either direction. If no Bradford frame is used, a board may be placed under this cross-bar. (Le Mesurier, courtesy of Jour. Bone and Joint Surg. and Maryland League for Crippled Children, Baltimore.)

the water should be between 88° and 96° F. A cupful of lukewarm water in which 2 tablespoonfuls of copper sulfate have been dissolved is poured into the tank once a week to prevent the water in the tank from becoming slimy.

Warm Springs, Georgia.—The institution at Warm Springs, Georgia, for patients convalescing from poliomyelitis is situated on Pine Mountain, 76 miles southwest of Atlanta, elevation about 1,200 feet. The late President Franklin D. Roosevelt, himself a victim of poliomyelitis, aided in its building. It has two swimming pools and two exercise pools which are fed from natural warm springs with water at a constant temperature of 89° F. The enclosed pool is 85 feet long, 35 feet wide, and 14 feet, 8 inches deep. The outside pool is 69 feet long, 35 feet

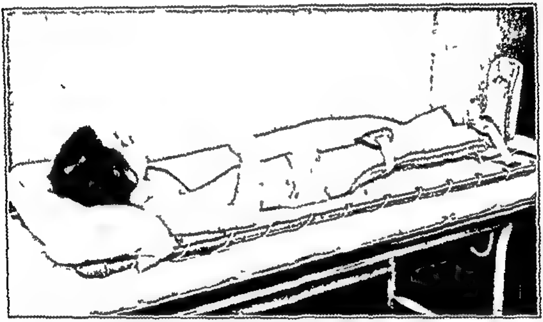


FIG. 287.—Toronto leg splint applied to patient on Bradford frame. The splint is padded fairly heavily and should require no further padding. The edges of the splint can be bent out if necessary by strong finger pressure. The strap around the thigh should be 1 or 2 inches above the patella and can be fixed at the proper level by the dome fasteners. The strap over the instep should be tight enough to hold the sole of the heel against the foot piece and to prevent any drop-foot deformity. No cradle is necessary as the foot piece is long enough to keep the bed clothes from pressing on the toes. A stocking may be worn under the straps of the splint. The whole leg should always be kept warm by sufficient bed coverings. The splint should be worn constantly but should be removed once a day for the necessary inspection and care of the skin. (Courtesy of Le Mesurier, Jour. Bone and Joint Surg. and the Maryland League for Crippled Children, Baltimore, Md.)

wide, and 3 feet 8 inches deep. In teaching a patient to walk, emphasis is placed on coordination and balance. These powers are restored more quickly by treatment under water than by other treatment. Before or after the exercises in the water, depending on the patient's reaction, sun baths modified to the tolerance of the patient, are given. The morning is taken up with exercises, swimming, and sun baths. Lunch is followed first by three hours of rest and then by walking exercises. Ramps and handrails are used to teach the patient balance and coordination in walking.

water during the exercises. Waterwings and overwater rings are helpful. Some swimming tanks have been outfitted with pulleys and ropes by which patients are suspended in the water. The combination of movements in the water tank and muscle reëducation exercises on the table is ideal.

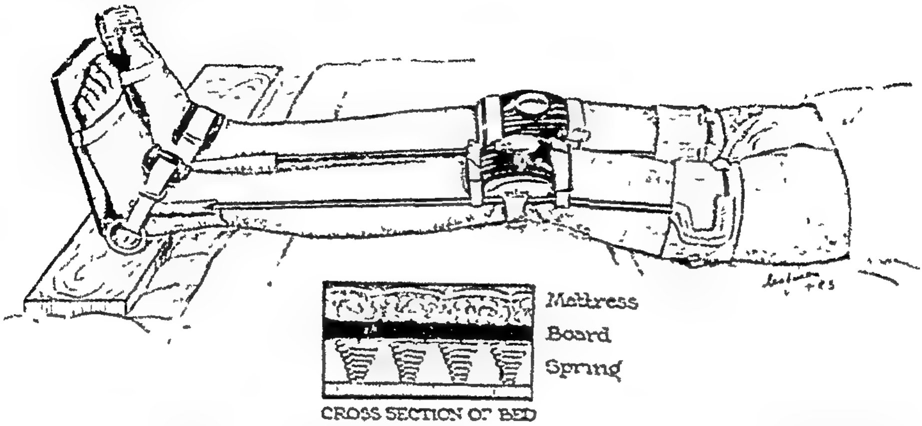


FIG. 285.—First aid or preliminary copper wire splint for prevention of deformities of foot, ankle and leg in poliomyelitis. Lower figure illustrates the "rigid mattress" made by inserting board underneath. (Redrawn from Legg and Merrill, Principles and Practice of Physical Therapy, courtesy of W. F. Prior Company.)

Pope Tank.—Margaret Pope performed her exercises more successfully while in a cypress tank 4½ feet high and 6 feet in diameter. It had a brass rail around the inside near the top. The temperature of

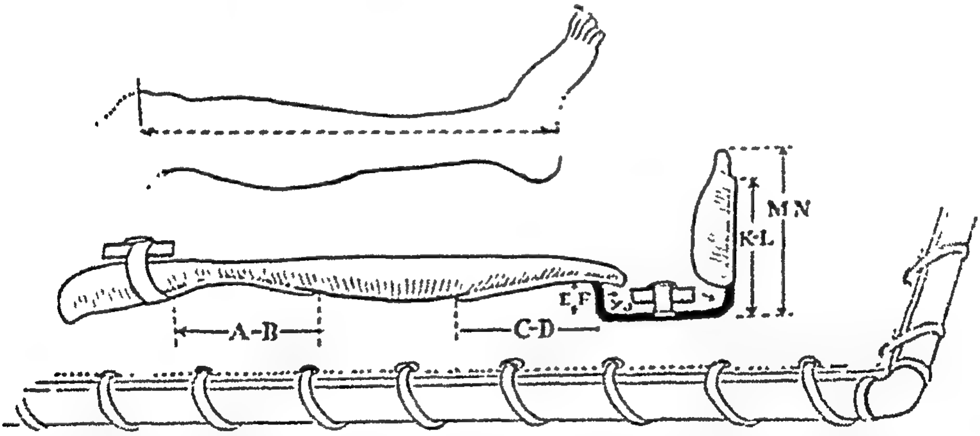


FIG. 286.—Toronto leg splint. This splint is intended to hold the knee slightly flexed and the foot at a right angle. If it is desired to hold the hip extended, a Bradford frame should be used and no pillows allowed under the shoulders. The cross-bar at the bottom of the splint is intended to prevent rotation of the limb in either direction If no Bradford frame is used, a board may be placed under this cross-bar. (Le Mesurier, courtesy of Jour. Bone and Joint Surg. and Maryland League for Crippled Children, Baltimore.)

the water should be between 88° and 96° F. A cupful of lukewarm water in which 2 tablespoonfuls of copper sulfate have been dissolved is poured into the tank once a week to prevent the water in the tank from becoming slimy.

Warm Springs, Georgia —The institution at Warm Springs, Georgia, for patients convalescing from poliomyelitis is situated on Pine Mountain, 76 miles southwest of Atlanta, elevation about 1,200 feet The late President Franklin D Roosevelt, himself a victim of poliomyelitis, aided in its building It has two swimming pools and two exercise pools which are fed from natural warm springs with water at a constant temperature of 89° F The enclosed pool is 85 feet long, 35 feet wide, and 14 feet, 8 inches deep The outside pool is 69 feet long, 35 feet

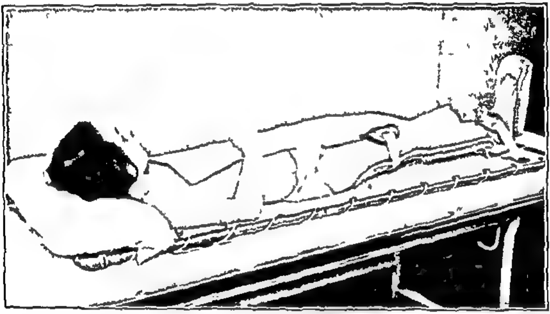


FIG 287 —Toronto leg splint applied to patient on Bradford frame The splint is padded fairly heavily and should require no further padding The edges of the splint can be bent out if necessary by strong finger pressure The strap around the thigh should be 1 or 2 inches above the patella and can be fixed at the proper level by the dome fasteners The strap over the instep should be tight enough to hold the sole of the heel against the foot piece and to prevent any drop-foot deformity No cradle is necessary as the foot piece is long enough to keep the bed clothes from pressing on the toes A stocking may be worn under the straps of the splint The whole leg should always be kept warm by sufficient bed coverings The splint should be worn constantly but should be removed once a day for the necessary inspection and care of the skin (Courtesy of Le Mesurier, Jour Bone and Joint Surg and the Maryland League for Crippled Children Baltimore, Md)

wide, and 3 feet 8 inches deep In teaching a patient to walk, emphasis is placed on coordination and balance These powers are restored more quickly by treatment under water than by other treatment Before or after the exercises in the water, depending on the patient's reaction, sun baths modified to the tolerance of the patient, are given The morning is taken up with exercises, swimming, and sun baths Lunch is followed first by three hours of rest and then by walking exercises Ramps and handrails are used to teach the patient balance and coordination in walking

water during the exercises. Waterwings and overwater rings are helpful. Some swimming tanks have been outfitted with pulleys and ropes by which patients are suspended in the water. The combination of movements in the water tank and muscle reëducation exercises on the table is ideal.

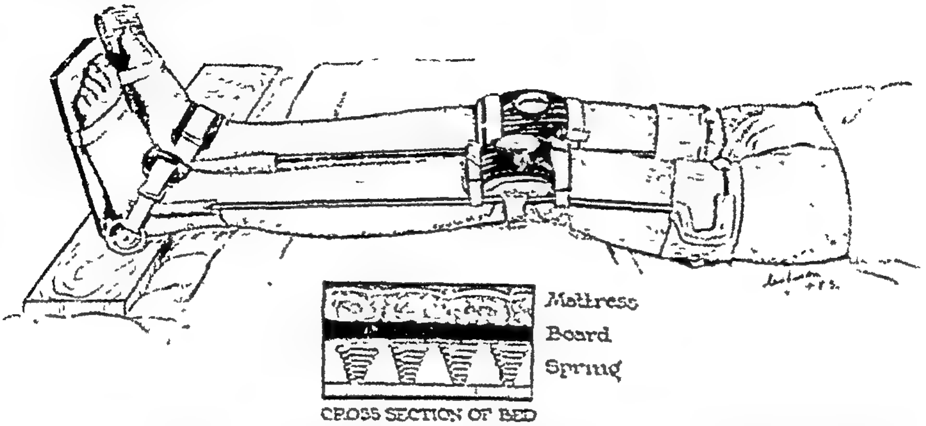


FIG. 285.—First aid or preliminary copper wire splint for prevention of deformities of foot, ankle and leg in poliomyelitis Lower figure illustrates the "rigid mattress" made by inserting board underneath. (Redrawn from Legg and Merrill, Principles and Practice of Physical Therapy, courtesy of W. F. Prior Company.)

Pope Tank.—Margaret Pope performed her exercises more successfully while in a cypress tank $4\frac{1}{2}$ feet high and 6 feet in diameter. It had a brass rail around the inside near the top. The temperature of

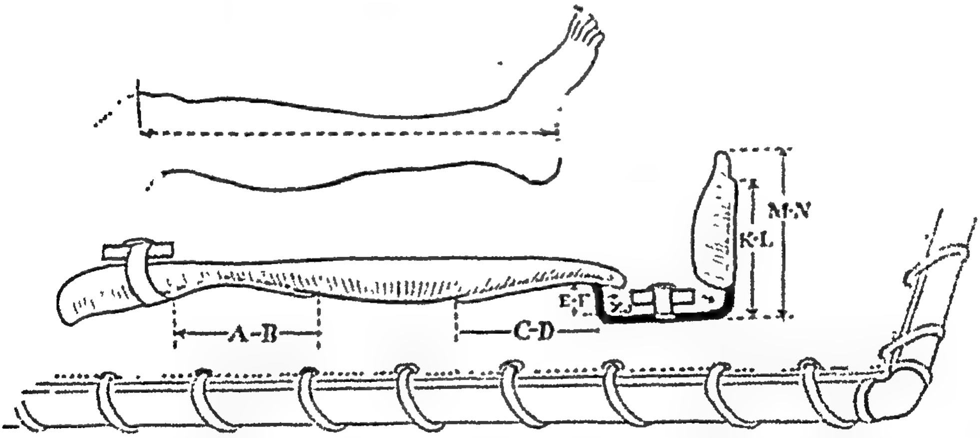


FIG. 286.—Toronto leg splint. This splint is intended to hold the knee slightly flexed and the foot at a right angle. If it is desired to hold the hip extended, a Bradford frame should be used and no pillows allowed under the shoulders. The cross-bar at the bottom of the splint is intended to prevent rotation of the limb in either direction If no Bradford frame is used, a board may be placed under this cross-bar. (Le Mesurier, courtesy of Jour. Bone and Joint Surg. and Maryland League for Crippled Children, Baltimore.)

the water should be between 88° and 96° F. A cupful of lukewarm water in which 2 tablespoonfuls of copper sulfate have been dissolved is poured into the tank once a week to prevent the water in the tank from becoming slimy.

Warm Springs, Georgia —The institution at Warm Springs, Georgia, for patients convalescing from poliomyelitis is situated on Pine Mountain, 76 miles southwest of Atlanta, elevation about 1,200 feet The late President Franklin D Roosevelt, himself a victim of poliomyelitis, aided in its building It has two swimming pools and two exercise pools which are fed from natural warm springs with water at a constant temperature of 89° F The enclosed pool is 85 feet long, 35 feet wide, and 14 feet, 8 inches deep The outside pool is 69 feet long, 35 feet

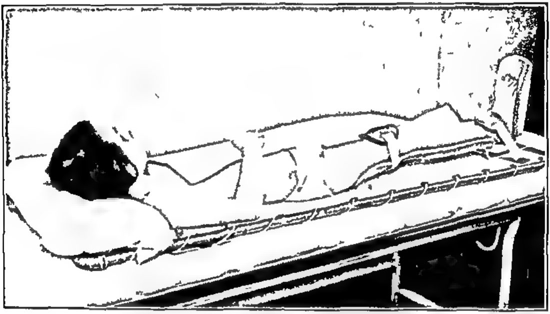


Fig 287 —Toronto leg splint applied to patient on Bradford frame The splint is padded fairly heavily and should require no further padding The edges of the splint can be bent out if necessary by strong finger pressure The strap around the thigh should be 1 or 2 inches above the patella and can be fixed at the proper level by the dome fasteners The strap over the instep should be tight enough to hold the sole of the heel against the foot piece and to prevent any drop-foot deformity No cradle is necessary as the foot piece is long enough to keep the bed clothes from pressing on the toes A stocking may be worn under the straps of the splint The whole leg should always be kept warm by sufficient bed coverings The splint should be worn constantly but should be removed once a day for the necessary inspection and care of the skin (Courtesy of Le Mesurier Jour Bone and Joint Surg and the Maryland League for Crippled Children Baltimore Md)

wide, and 3 feet 8 inches deep In teaching a patient to walk, emphasis is placed on coordination and balance These powers are restored more quickly by treatment under water than by other treatment Before or after the exercises in the water, depending on the patient's reaction, sun baths modified to the tolerance of the patient, are given The morning is taken up with exercises, swimming, and sun baths Lunch is followed first by three hours of rest and then by walking exercises Ramps and handrails are used to teach the patient balance and coordination in walking

Stationary Bicycle.—A valuable exercise during the latter part of the subacute stage is stationary bicycle riding. The patient should ride forward and backward with and without friction on the back wheel tire. The frequency of the periods and their duration should be graduated. The handle bars, seat, and pedals should be adjusted to the patient. While the patient is riding, his naked back should be carefully observed. A back support may be added, or the patient may wear a Taylor spine brace or a Hoke corset.

Stair climbing is a valuable exercise when done under supervision. Another beneficial exercise is walking over hurdles or a ladder on the floor.

Treatment During the Chronic Stage.—The chronic stage begins after spontaneous recovery has ceased. During this stage, massage, electrical treatment, and muscle reëducation are continued, but because the chance of natural improvement is diminishing, attention is directed chiefly to the correction of deformities.

During the early stages, the majority of deformities can be prevented by proper orthopædic care. The most effective means of preventing deformity in the early stages is plaster in the form of well-padded splints or in the form of circular casts which are later bivalved.

Legg emphasized the importance of the following factors as causes of deformity: overfatigue, general exercise without regard to muscle balance, and weight-bearing without mechanical support in positions favoring deformity. To these I would add the effects of gravity, habitually incorrect posture, unprotected premature functional use, muscle imbalance, and contractures. All muscles work in pairs; when one muscle is paralyzed its antagonist, if not prevented, contracts, thereby allowing contraction of ligaments, capsules and fasciæ. If a paralyzed extensor muscle is opposed by a normal flexor muscle, the latter will produce a flexion deformity. If the tibial muscles alone are weakened, the peroneals will produce a valgus deformity.

Among the common deformities are flexion contracture at the hips, flexion of the knees, plantar flexion and lateral deviation of the feet and hyperextension at the metacarpophalangeal joints. A deformity should be corrected as soon as it becomes apparent. Correction is accomplished by means of plaster casts, braces, manipulative treatment and operations. Gradual correction is often preferable to correction by operation. Muscles cannot be expected to correct bony deformity or to take up the work of stronger muscles. Operations to restore stability are usually not performed until two years after the onset of the disease, and not until the child is seven or preferably ten years of age. In the meantime, precautions should be taken to hold the deformity in check.

Teaching the Patient to Walk With Crutches—The patient who is given crutches must be instructed in their use Crutches should be of such a length and the hand rests should be so spaced that the weight of the body will come on the hands and not under the axillæ The axillary rests should be padded (See page 118)

FIG 288—Light steel spring brace to support the ankle in 15 degrees of plantar flexion and prevent talipes calcaneus limp Note ⅜ inch elevation inside shoe (Redrawn from Miltner and Wan courtesy of Jour Bone and Joint Surg)

Lovett said that two classes of patients come to the surgeon those who cannot walk and wish to walk, and those who can walk but wish to walk better Persons with very little strength in the legs, hips, abdomen and back can be taught to walk, to sit down upon and get up from a chair, and, frequently, even to go up and down stairs The two latter achievements constitute the difference between dependence and independence A patient paralyzed below the waist who has one arm strong enough to hold a crutch can be taught to walk by the "tripod" method Lovett describes this as follows If the crutches are placed apart and slanted well forward at their lower ends they form the two anterior legs of the tripod, while the third and posterior

Stationary Bicycle.—A valuable exercise during the latter part of the subacute stage is stationary bicycle riding. The patient should ride forward and backward with and without friction on the back wheel tire. The frequency of the periods and their duration should be graduated. The handle bars, seat, and pedals should be adjusted to the patient. While the patient is riding, his naked back should be carefully observed. A back support may be added, or the patient may wear a Taylor spine brace or a Hoke corset.

Stair climbing is a valuable exercise when done under supervision. Another beneficial exercise is walking over hurdles or a ladder on the floor.

Treatment During the Chronic Stage.—The chronic stage begins after spontaneous recovery has ceased. During this stage, massage, electrical treatment, and muscle reëducation are continued, but because the chance of natural improvement is diminishing, attention is directed chiefly to the correction of deformities.

During the early stages, the majority of deformities can be prevented by proper orthopædic care. The most effective means of preventing deformity in the early stages is plaster in the form of well-padded splints or in the form of circular casts which are later bivalved.

Legg emphasized the importance of the following factors as causes of deformity: overfatigue, general exercise without regard to muscle balance, and weight-bearing without mechanical support in positions favoring deformity. To these I would add the effects of gravity, habitually incorrect posture, unprotected premature functional use, muscle imbalance, and contractures. All muscles work in pairs; when one muscle is paralyzed its antagonist, if not prevented, contracts, thereby allowing contraction of ligaments, capsules and fasciæ. If a paralyzed extensor muscle is opposed by a normal flexor muscle, the latter will produce a flexion deformity. If the tibial muscles alone are weakened, the peroneals will produce a valgus deformity.

Among the common deformities are flexion contracture at the hips, flexion of the knees, plantar flexion and lateral deviation of the feet and hyperextension at the metacarpophalangeal joints. A deformity should be corrected as soon as it becomes apparent. Correction is accomplished by means of plaster casts, braces, manipulative treatment and operations. Gradual correction is often preferable to correction by operation. Muscles cannot be expected to correct bony deformity or to take up the work of stronger muscles. Operations to restore stability are usually not performed until two years after the onset of the disease, and not until the child is seven or preferably ten years of age. In the meantime, precautions should be taken to hold the deformity in check.

Teaching the Patient to Walk With Crutches.—The patient who is given crutches must be instructed in their use. Crutches should be of such a length and the hand rests should be so spaced that the weight of the body will come on the hands and not under the axillæ. The axillary rests should be padded. (See page 118.)

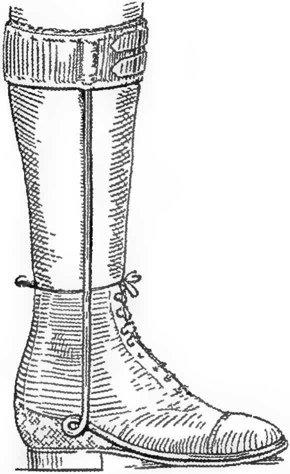


Fig. 288.—Light steel spring brace to support the ankle in 15 degrees of plantar flexion and prevent talipes calcaneus limp. Note $\frac{3}{8}$ inch elevation inside shoe. (Redrawn from Miltner and Wan, courtesy of Jour. Bone and Joint Surg.)

Lovett said that two classes of patients come to the surgeon; those who cannot walk and wish to walk, and those who can walk but wish to walk better. Persons with very little strength in the legs, hips, abdomen and back can be taught to walk, to sit down upon and get up from a chair, and, frequently, even to go up and down stairs. The two latter achievements constitute the difference between dependence and independence. A patient paralyzed below the waist who has one arm strong enough to hold a crutch can be taught to walk by the "tripod" method. Lovett describes this as follows: If the crutches are placed apart and slanted well forward at their lower ends they form the two anterior legs of the tripod, while the third and posterior

leg is formed by the body of the patient, inclined forward, with the feet well behind.

Limps and Gaits.—Paralysis of various muscles is accompanied by characteristic limps and gaits, for example:

Gluteus medius: The gait is like the lurch produced by a short leg.

Gluteus maximus: The gait is like that of a patient who has had an amputation and is wearing an artificial leg.

Adductors: The patient is unable to place one foot in front of the other and must therefore swing his body.

Flexors of the thighs: There is a forward twist of the pelvis.

Quadratus lumborum: There is a peculiar backward thrust of the trunk.

Quadriceps extensor: The patient locks his knee with his hand placed above the knee. (In cases of quadriceps weakness, a certain degree of equinus is desirable.)

Schwartz and Zaeth described an instrument called the "basograph" which, when attached to the pelvis, makes a record of deforming limps which can be compared with records of the gaits of normal persons.

Two forms of lameness of primary importance are due to paralysis of the glutei medius and maximus. According to Lovett, the functions of the gluteus medius muscle are to abduct the thigh on the body and, when the leg is on the ground, to raise the other side of the pelvis in walking. If this muscle is paralyzed, the patient compensates by leaning the trunk over on the affected leg, balancing in this way and thus permitting the other side of the pelvis to be raised from the ground. The limp is a sudden lurch to the side when weight is borne on the affected leg, and is indistinguishable from the limp caused by shortening. It can be minimized by the use of a corset and leg brace connected by a heavy elastic strap running down over the trochanter and acting in the same line as the pull of the gluteus medius.

The gluteus maximus extends the thigh on the body and, when the leg is the fixed point, holds the trunk erect on the legs. When, in paralysis of this muscle, weight is borne on the affected leg, the trunk is thrown back and the hip is hyperextended. The limp is similar to that of a patient wearing an artificial limb following an amputation above the knee. The posture assumed establishes balance and compensates for the loss of the extensor muscles of the thigh. Lovett found that a heavy elastic posterior strap applied from a belt or a corset to a leg brace diminished the limp. The strap must be attached to the brace below the knee or the patient will be unable to sit down, because unless the knee is bent, the elastic strap draws across the buttock causing uncomfortable pressure.

Two other, though less important limps, are due to paralysis of the iliopsoas and the tensor fasciæ femoris muscles.

Plastridge's Outline of Gaits —This outline is based on the assumption that all muscles are strong except the muscle mentioned

1 Gluteus maximus As the weight is placed on the affected leg and the other foot is raised from the floor, the body swings diagonally backward toward the side of the weakness

2 Glutei medius and minimus As the weight is placed on the affected leg, the body sways sideways toward the side of the weakness, and the arm on that side is thrown sideways to help maintain balance

3 Adductors The feet are placed somewhat further apart than is normal, and each foot tracks in front of itself instead of, as in normal walking, in front of the opposite foot This is the so-called "snowshoe limp" There is inability to walk a chalk line, but no asymmetrical limp

4 Hip flexors When the leg cannot be lifted sufficiently to place it forward for a step, a whole side of the body is flung forward and the leg dragged after it This appears to rotate the opposite leg inward

5 Inward rotators The leg rolls outward from the hip

6 Outward rotators The leg rolls inward from the hip and the gait is pigeon-toed

7 Quadriceps (*a*) The hand is placed on the knee or thigh to hold the knee stiff enough to bear weight, *i e*, to lock the knee

(*b*) The leg is rotated outward to stiffen the knee enough to bear weight The forward thrust of the body will not bend the knee through its lateral axis

(*c*) The body is bent forward from the hips and the knee thrust backward The knee may even be hyperextended

(*d*) With an equinus, the weight is borne on the toe and the body is bent slightly forward from the hips while the knee is forced back

(*e*) If both quadriceps are weak, the body is bent forward constantly

8 Hamstrings The knee is hyperextended with each step, and walking is arrhythmical

9 Dorsal flexors The knee is raised higher than normal to prevent the dropped toe from scraping, and when the foot strikes the ground there is a double contact, the toe touching first, then the heel

10 Posterior tibial The foot is held in valgus and the walk is "flat-footed"

11 Anterior tibial The foot is held in valgus and the gait is like that of a flat-footed person

12 Peroneals The foot is held in varus, and the weight is borne on the outer border of the foot

13 Gastrocnemius There is no power to the "push off" with the front part of the foot, and the heel is never lifted to make a "springy"

step. As the weight is placed on the foot, the toe flexors contract and pull the heel toward the toes, exaggerating the arch of the foot and giving it a shortened appearance. This limp may sometimes be reduced by trying to get the "push off" with the knee instead of the ball of the foot.

There are other rather complicated gaits due to unusual combinations of weaknesses which are impossible to imitate when the muscles are normal.

As a gait due to involvement of only one group of muscles is rare, there are usually several confusing and seemingly conflicting actions which are difficult to differentiate.

Fractures.—Fractures occurring in extremities paralyzed by poliomyelitis are frequently due to the patient's inability to protect himself from falling. The fracture seems to be mid-way between a traumatic and a pathological fracture. Bones in paralytic extremities undergo atrophy, but this does not prevent callus formation. The callus may be weak because of the absence of good muscle tone around the bone and functional disuse.

SURGICAL TREATMENT OF THE RESIDUAL EFFECTS OF ANTERIOR POLIOMYELITIS

If possible, operation should be avoided before the age of nine or ten years. As a rule, no major operation should be performed within two years after the acute attack. The indications for operation are to improve function and stability, to correct deformity, and to get rid of braces. The types of operations include osteotomy, arthrodesis, resection of bone, plastic operations, and tendon plastics and transplantations.

In the cases of young patients with poliomyelitis, operation may be followed by acidosis. The preventive treatment for acidosis consists of the free administration of fruit juices, sweets and calcium preparations. Other measures consist of the administration of fresh pressed apple juice, other fruit juices and lemon stick candy. The intravenous use of dextrose is recommended.

After orthopædic operations, the affected parts should be elevated and vigilance should be maintained to detect signs of swelling, discoloration, and hemorrhage. Severe persistent pain is a warning signal.

Dunn advocates gradual correction of deformity. Division of tight structures usually means division of active muscles. Division weakens a muscle, thereby rendering it less effective in the control of the limb or of less value for transplantation.

Sympathectomy.—Harris found that it is possible to accelerate the growth of a child's leg by lumbar sympathectomy, and that this opera-

tion renders the patient more comfortable, by transforming a foot which is cold, blue and moist, to one which is warm and dry

Operations on Soft Tissues—Operations on soft tissues include tendon lengthening, shortening, transplantation and fixation, muscle transplantation, silk ligament suspension and fascial transplantation

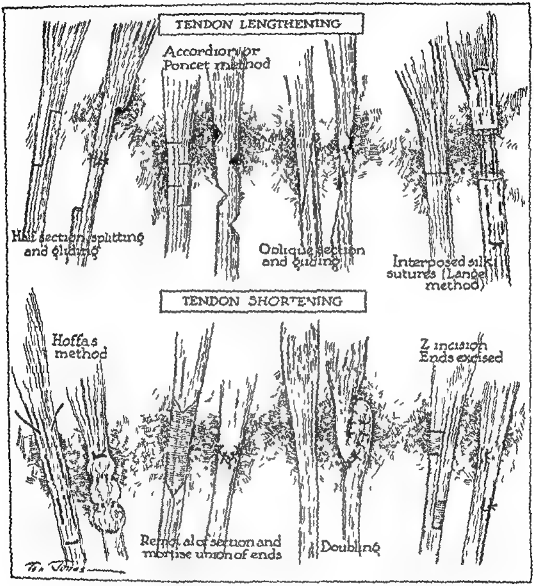


Fig 289—(Reproduced with permission of Johnson & Johnson)

Tendon Lengthening—The chief tendons operated upon are the Achilles and the hamstrings The types of tendon lengthening are subcutaneous tenotomy and plastic lengthening

A tendon may be lengthened by making a subcutaneous incision halfway through it on one side and another such incision at an equal distance on the other side, and then forcibly stretching the tendon The open operation has superseded the subcutaneous method At

open operation, lengthening may be accomplished by the Z-method, that is, making a longitudinal incision through the middle of the tendon, next cutting halfway through it on one side above and on the other side below, and then allowing the tendon to slip upon itself. After the desired lengthening has been obtained, a few catgut sutures are inserted. Among other plastic operations for tendon lengthening is the Sporon-Hibbs method in which an L-shaped incision is made in the tendon and an inverted L outlined within the first incision.

In one of the two methods of tendon lengthening which I devised, two longitudinal incisions are made parallel with the long axis of the tendon. The outer and inner cross cuts are made above and the middle one is made below. The tendon is then lengthened the desired amount by causing one tongue-shaped portion of the tendon to slide in between the two other portions.

Tendon Shortening.—One method of tendon shortening consists in making a step-like incision through the tendon and suturing it with catgut. In another, a section of the tendon is cut out and the ends are sutured with catgut. A stretched tendon which has been shortened must be protected against restretching.

Tendon Transplantation and Transposition.—Tendon transplantation or transposition is transference of the tendon of a functioning muscle to replace the tendon of a paralyzed muscle. The procedure was originated by Nicoladoni and further developed by Lange. Lange's work was soon followed by that of Biesalski and Mayer.

In three classical papers on the physiological method of tendon transplantation, Mayer has given an excellent description of this method. In the first paper he deals with the historical aspects, anatomy, and physiology of tendons; in the second, he describes the operative technic; and in the third, he reports experimental and clinical experiences. He outlines the physiological requirements of a tendon operation, and describes three typical physiological tendon transplantations: (1) transplantation of the extensor proprius hallucis as a substitute for the tibialis anticus; (2) conversion of the tibialis anticus into an abductor and pronator; and (3) transplantation of the peroneus longus as a substitute for the tibialis anticus.

Steindler's work on tend[illegible] on the principles laid down by Lange, Biesalski, and Ma[illegible] the tendon together with its sheath and perit[illegible] event slipping of the transplanted tendon [illegible] a technic in which either the recipien[illegible] ndon is u ed as a living suture. Lange [illegible] don with parch[illegible] t.

The [illegible] d and a side[illegible]

The principles of tendon transplantation require

1 The use of a tendon of sufficient strength The transplanted tendon must be nearly as strong as the normal strength of the tendon it is to replace

2 Careful selection of the site of implantation

3 Determination of the route to be traversed The tendon must not be compelled to angulate, it must have an oblique direction Most commonly, a tunnel is made for it in the subcutaneous tissues

4 Accurate fixation or anchorage of the transplanted tendon to bone periosteum, another tendon, fascia, or muscle

5 The avoidance of too much tension upon, and of too much slackness of the transplanted tendon

6 The avoidance of trauma

7 The prevention of hemorrhage by the use of a constrictor, careful dissection, and moderate pressure of the dressing to prevent oozing

8 Retention of the transplanted tendon in the proper position The materials used for securing tendons (tenodesis) are chromic catgut, silk (Lange), and metal screws (Putti)

9 Postoperative care, including elevation of the limb, careful observation, and early active and passive movements within narrow limits

Success depends upon whether the transposed tendon will perform its new functions naturally or can be educated to perform them, and whether it is sutured under the proper degree of tension

In the transplantation of tendons in the foot, the tibialis anticus may be secured to the outer side of the tarsus and the extensor hallucis longus to take the place of the tibialis anticus

In extension of the ankle, the posterior tibial and peroneal muscles function with the tendon of Achilles and therefore can be used to replace one another

For cases of weakness of the anterior tibial group, Dunn recommends tendon fusion uniting all the muscles on the front of the leg He exposes all of the anterior tibial tendon above the ankle, dissects away the fascia covering them, incises opposing tendon surfaces, and then exposes and unites the inner surfaces of the tendons

Some of the imperfect results of tendon suture are due to prolonged immobilization A tendon suture must permit early function and must not strangulate the tendon The Frisch suture, which begins well back of the line of division and merely grasps the tendon at three points on each side, gives sufficient purchase on the tendon to permit early motion and does not strangulate The cut surfaces of the tendon may be accurately approximated by interrupted catgut sutures The patient may use the tendon as soon as he desires

open operation, lengthening may be accomplished by the Z-method, that is, making a longitudinal incision through the middle of the tendon, next cutting halfway through it on one side above and on the other side below, and then allowing the tendon to slip upon itself. After the desired lengthening has been obtained, a few catgut sutures are inserted. Among other plastic operations for tendon lengthening is the Sporon-Hibbs method in which an L-shaped incision is made in the tendon and an inverted L outlined within the first incision.

In one of the two methods of tendon lengthening which I devised, two longitudinal incisions are made parallel with the long axis of the tendon. The outer and inner cross cuts are made above and the middle one is made below. The tendon is then lengthened the desired amount by causing one tongue-shaped portion of the tendon to slide in between the two other portions.

Tendon Shortening.—One method of tendon shortening consists in making a step-like incision through the tendon and suturing it with catgut. In another, a section of the tendon is cut out and the ends are sutured with catgut. A stretched tendon which has been shortened must be protected against restretching.

Tendon Transplantation and Transposition.—Tendon transplantation or transposition is transference of the tendon of a functioning muscle to replace the tendon of a paralyzed muscle. The procedure was originated by Nicoladoni and further developed by Lange. Lange's work was soon followed by that of Biesalski and Mayer.

In three classical papers on the physiological method of tendon transplantation, Mayer has given an excellent description of this method. In the first paper he deals with the historical aspects, anatomy, and physiology of tendons; in the second, he describes the operative technic; and in the third, he reports experimental and clinical experiences. He outlines the physiological requirements of a tendon operation, and describes three typical physiological tendon transplantations: (1) transplantation of the extensor proprius hallucis as a substitute for the tibialis anticus; (2) conversion of the tibialis anticus into an abductor and pronator; and (3) transplantation of the peroneus longus as a substitute for the tibialis anticus.

Steindler's work on tendons is based on the principles laid down by Lange, Biesalski, and Mayer Bernstein transfers the tendon together with its sheath and peritendinous structures. To prevent slipping of the transplanted tendon after fixation, Royle devised a technic in which either the recipient tendon or the transplanted tendon is used as a living suture. Lange surrounds the tendon or artificial silk tendon with parchment.

The physiological and anatomical factors must be carefully considered.

The principles of tendon transplantation require

1 The use of a tendon of sufficient strength The transplanted tendon must be nearly as strong as the normal strength of the tendon it is to replace

2 Careful selection of the site of implantation

3 Determination of the route to be traversed The tendon must not be compelled to angulate, it must have an oblique direction Most commonly, a tunnel is made for it in the subcutaneous tissues

4 Accurate fixation or anchorage of the transplanted tendon to bone periosteum, another tendon, fascia, or muscle

5 The avoidance of too much tension upon, and of too much slackness of the transplanted tendon

6 The avoidance of trauma

7 The prevention of hemorrhage by the use of a constrictor, careful dissection, and moderate pressure of the dressing to prevent oozing

8 Retention of the transplanted tendon in the proper position The materials used for securing tendons (tenodesis) are chromic catgut, silk (Lange), and metal screws (Putti)

9 Postoperative care, including elevation of the limb, careful observation, and early active and passive movements within narrow limits

Success depends upon whether the transposed tendon will perform its new functions naturally or can be educated to perform them, and whether it is sutured under the proper degree of tension

In the transplantation of tendons in the foot, the tibialis anticus may be secured to the outer side of the tarsus and the extensor hallucis longus to take the place of the tibialis anticus

In extension of the ankle, the posterior tibial and peroneal muscles function with the tendon of Achilles and therefore can be used to replace one another

For cases of weakness of the anterior tibial group, Dunn recommends tendon fusion uniting all the muscles on the front of the leg He exposes all of the anterior tibial tendon above the ankle, dissects away the fascia covering them, incises opposing tendon surfaces, and then exposes and unites the inner surfaces of the tendons

Some of the imperfect results of tendon suture are due to prolonged immobilization A tendon suture must permit early function and must not strangulate the tendon The Frisch suture, which begins well back of the line of division and merely grasps the tendon at three points on each side, gives sufficient purchase on the tendon to permit early motion and does not strangulate The cut surfaces of the tendon may be accurately approximated by interrupted catgut sutures The patient may use the tendon as soon as he desires

In the repair of a tendon, not only the tendon cells but also the epitenon and peritenon play an important part.

After a partially paralyzed muscle has been reinforced by tendon or muscle transplantation and held for a considerable period in a position of physiological rest, it will exhibit some return of power.

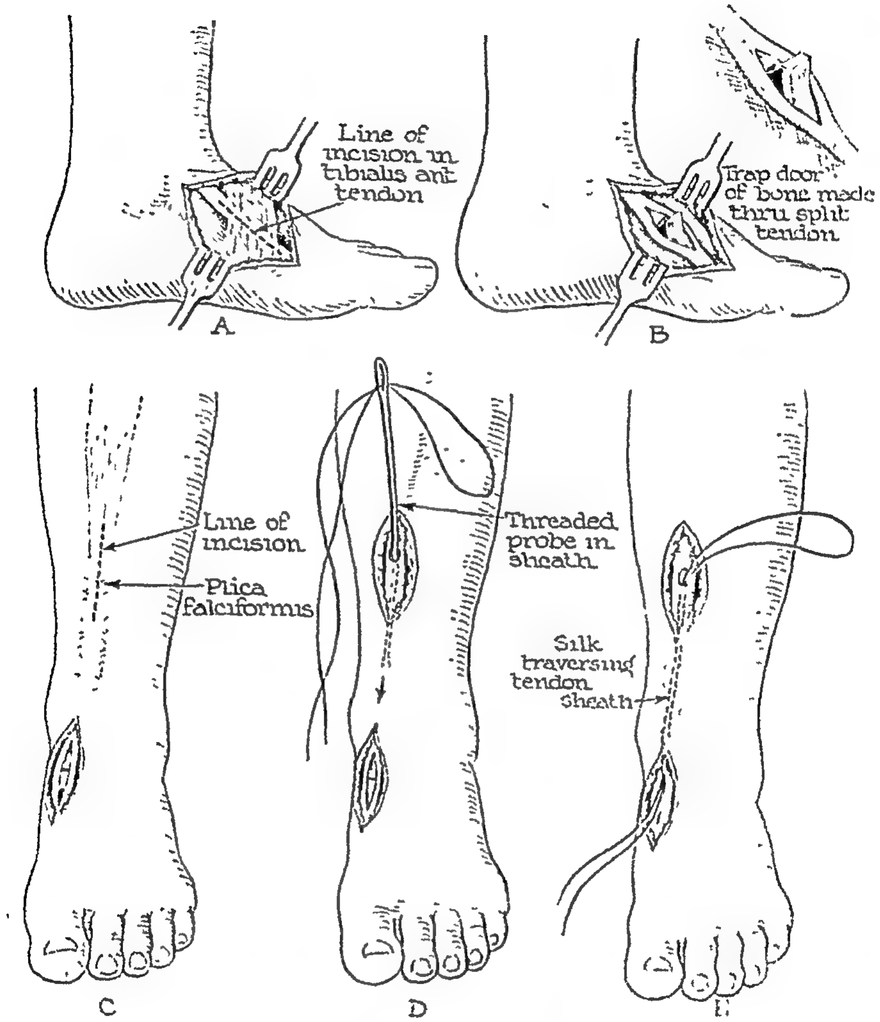


FIG 290.—*A*, Tibialis anticus is slit longitudinally for 1½ inches at its insertion. *B*, A trap door of bone is lifted up at the insertion of the tibialis anticus. Beneath this trap door the peroneal tendon will be buried at the final step of the operation. *C*, Incision at the upper pole of the tibialis anticus sheath. *D*, A probe threaded with a silk guide suture enters the upper pole of the sheath of the tibialis anticus. *E*, The probe has passed through the sheath, emerged on the dorsum of the foot near the insertion of the tibialis anticus and has been drawn through, leaving a loop of silk traversing the tendon sheath. (Redrawn by courtesy of Leo Mayer and Surg., Gyn. and Obs.)

Mayer's Physiological Tendon Transplantation (Figs. 290, 291 and 292).—The following are descriptions of three typical physiological tendon transplantations as given by Mayer in three articles published in *Surgery, Gynecology and Obstetrics*.

I *Transplantation of the Extensor Proprius Hallucis for the Tibialis Anticus* —In cases of slight paralytic valgus

1 The first skin incision, 4 cm long, bowed with its convexity toward the sole of the foot, is made over the insertion of the tibialis anticus

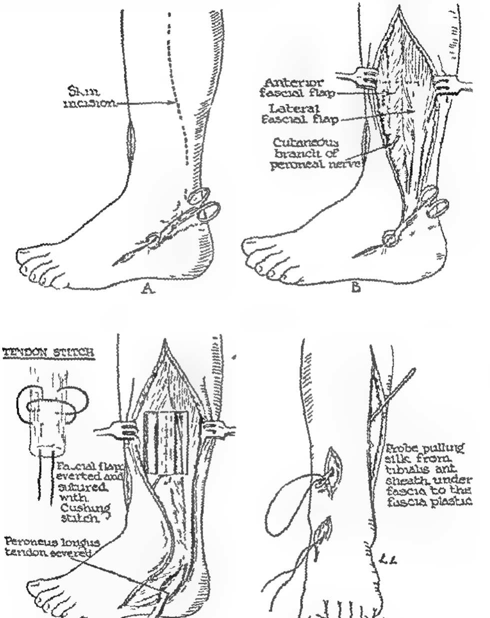


FIG 291 —*A* If an arthrodesis has been performed this skin incision is closed temporarily *B* Two rectangular fascial flaps are outlined one over the anterior muscular compartment the other over the lateral *C* The fascial flaps have been everted exposing their deep surface which is coated with gliding tissue A Cushing stitch has been taken uniting the fascial edges thus forming a physiological bridge for the tendon to be transplanted The peroneus longus tendon has been severed just before it enters the groove in the cuboid Insert shows tendon stitch *D* A probe is passed from the upper pole of the tibialis anticus sheath beneath the fascia to the fascia plastic The loop of silk is threaded into the probe and drawn through with it (Redrawn by courtesy of Leo Mayer and Surg Gyn and Obs)

2. Preparation of the implantation site for the extensor hallucis longus. The tendon of the tibialis anticus at its insertion is slit longitudinally for 3 or 4 cm., and the bone or cartilage of the internal cuneiform is grooved for the reception of the extensor tendon.

3. The incision over the extensor proprius hallucis tendon runs in the line of the tendon from a point 3 cm. above the tip of the internal malleolus to the middle of the first metatarsal bone. The tendon is left *in situ* until all has been made ready for transferring it into the

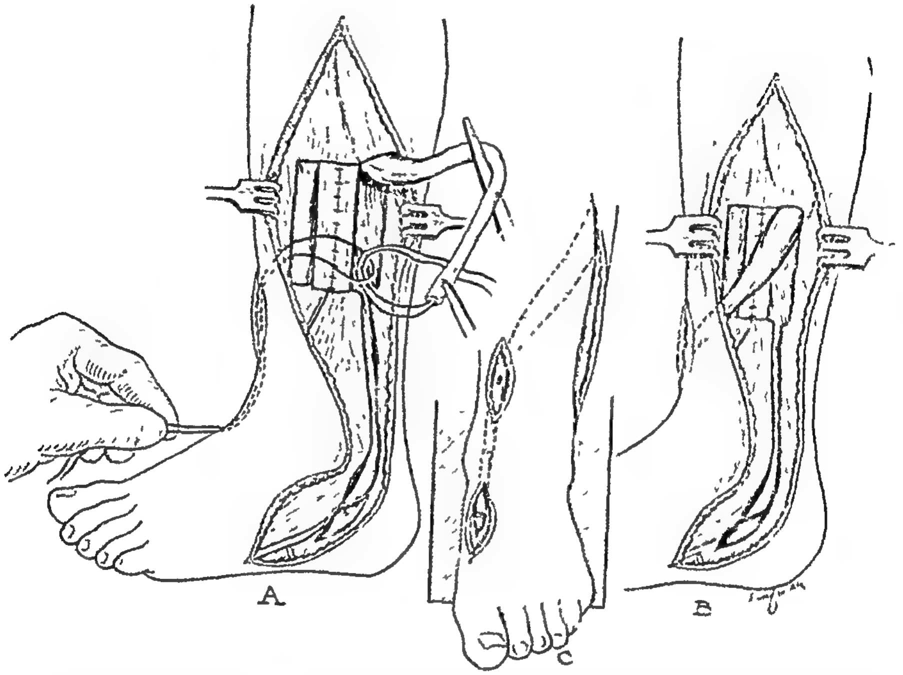


Fig. 292.—The tendon suture inserted into the peroneus longus is passed within the loop of the guide suture. The operator grasps the peroneal tendon and starts it on its pathway beneath the fascia. An assistant pulling on the loose ends of the guide suture draws the tendon gently down through the sheath of the tibialis anticus. *B*, The peroneus longus is seen passing over the fascial bridge in its course toward the upper pole of the tibialis anticus sheath. *C*, The peroneus tendon is seen traversing the sheath of the tibialis anticus to its new insertion. By means of the tendon stitch the peroneal tendon is fastened securely beneath the trap door of bone, shown in second step of operation. The slit tibialis anticus is drawn together on each side of the peroneal tendon (Redrawn by courtesy of Leo Mayer and Surg., Gyn. and Obs.)

sheath of the tibialis anticus. At a point about 2 cm. above the malleolus the septum separating the tendon is very thin. Here the operator can draw the extensor tendon into the sheath of the tibialis anticus.

4. The fascia over the extensor must be incised for 2 or 3 cm. proximal to the sheath. The mesial fascial edge is grasped with a clamp and raised until the operator sees this thin portion of the septum. Here a small incision is made directly into the tibialis sheath. An eye-probe passed through this incision in the line of the tibialis tendon

is made to puncture the lower end of the sheath and to appear over the insertion of the tendon

5 The sheath of the extensor hallucis tendon is then slit open its entire length The tendon is divided near the middle of the metatarsal bone, its end grasped with a tendon clamp, and the mesotenon divided close to the tendon until the operator reaches the lowermost muscle fibers

The vessels of the mesotenon are thus sacrificed, but a large vessel which runs through the lowermost muscle fibers can always be spared The tendon end is threaded with chromic catgut, the free ends of the suture are passed into the eye of the probe, and the tendon is thus drawn through the sheath of the tibialis anticus

6 Fixation of the tendon To give the transplanted tendon the exact physiological tension, one approximates the origin of the muscle and its new point of insertion by holding the foot supinated and flexed dorsally, draws the tendon downward until it runs in a straight line, and sutures it under just sufficient tension to maintain this desired course The implantation site is prepared by slitting the tibialis tendon lengthwise and scarifying the periosteum of the internal cuneiform bone The tendon, threaded by a fixation suture, is now fastened securely between the two halves of the tibialis tendon The sutures are threaded on a heavy "cervix needle" or an instrument resembling a shoemaker's awl, and are passed through bone or cartilage, ligament and fascia The fixation must be mechanically secure When properly executed, it can withstand 20 to 30 pounds of traction Slipping is prevented by suturing the paralyzed tibialis tendon over the extensor hallucis

7 The distal stump of the extensor tendon is fastened to the adjacent tendon of the extensor longus digitorum, the fascia is closed, and thus the normal ligaments of the foot are restored The skin incisions are closed without drainage

II *Conversion of the Tibialis Anticus Into an Abductor and Pronator* —This operation is indicated in cases of paralytic talipes varus It should be performed only when a marked degree of correction is required When slighter grades of varus are present, the extensor proprius hallucis should be used instead of the tibialis anticus The two operations are so nearly alike that the description of one suffices

1 A 4-cm curved incision is made over the insertion of the peroneus tertius Skin, fascia, and subcutaneous tissue are retracted to form a flap

2 The tendon of the peroneus tertius is then slit for several centimeters, and the metatarsal bones are grooved for the reception of the tibialis anticus

3 An incision is made in the course of the tibialis anticus tendon

from the upper pole of its sheath, 3 to 5 cm. above the malleolus, to its insertion. The sheath is opened near its upper pole.

4. The lateral margin of the divided fascia just proximal to the upper pole of the tibialis sheath is retracted until the extensor longus digitorum is visible. This level lies above the upper pole of the extensor sheath. To enter the sheath, the loose connective tissue surrounding the extensor tendons—the paratenon—is incised until the bare tendon sheath is reached. A probe passed along the tendon is then certain to

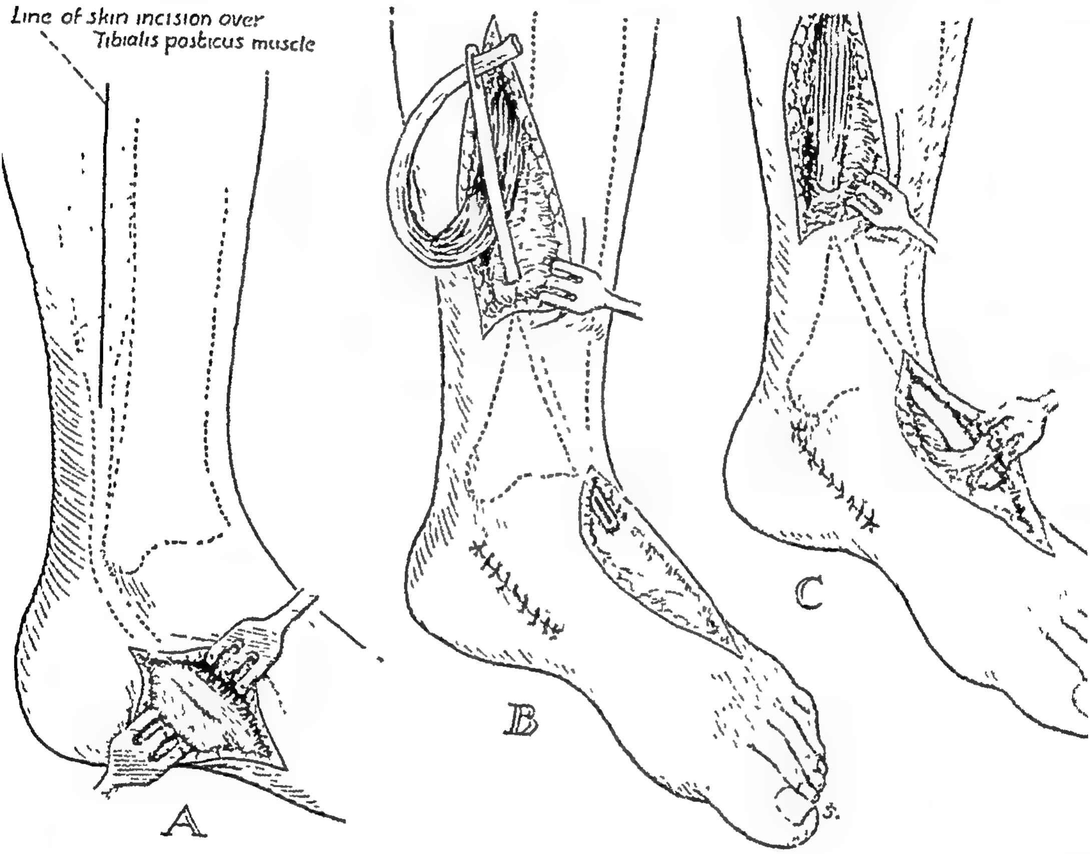


FIG. 293 —Forward transference of tibialis posticus tendon (technic of Ober). *A*, Exposure of tibialis posticus tendon. *B*, Belly of muscle dissected free from tibia and passed through anterior tibial compartment to dorsum of foot *C*, Insertion of posterior tibial tendon into second and third metatarsal bones. (Redrawn from Ober, New England Jour. Med ; Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

enter the sheath. Passing the probe through the sheath again calls for a knowledge of its inner architecture. All five tendons, four extensors, and the peroneus tertius are connected with one another by means of a common mesotenon. The operator must be careful to pass the probe superficially to the tendons; otherwise he will draw the tibialis anticus between the extensor tendons and thus interfere with their function as well as that of the transplanted tendon. The probe is guided in the direction of the peroneus tertius, made to puncture

the lower pole of the sheath, and made to appear between the fascia and the tendon near its insertion

5 The sheath of the tibialis anticus is now slit open in its entire length and the fascia below the sheath incised until the insertion of the tendon is visible The tendon must be divided as near the bone as possible, otherwise it will not be long enough to reach its new point of insertion It is then threaded with strong chromic gut and freed from its mesotenon until it can run a direct course into the sheath of the extensor longus digitorum and peroneus tertius

6 The tendon is drawn through the sheath by means of an eye-probe and fastened to the bone and to the peroneus tertius tendon Care must be taken that the course of the tendon is straight, and that the muscle is not twisted

III *Transplantation of the Peroneus Longus for the Tibialis Anticus* —This operation is indicated in cases of paralytic talipes valgus As usually performed, it does not efficiently replace the paralyzed tibialis anticus for unless the peroneal tendon runs through the sheath of the tibialis anticus tendon, a supinating effect is impossible A fascial plastic operation is performed as follows

1 Incision over the insertion of the tibialis anticus and preparation of the implantation site by slitting the tibialis tendon and grooving the internal cuneiform

2 A 3-cm incision near the upper pole of the tibialis sheath enables one to open the sheath and to pass a probe threaded with a guide-suture through it to the insertion of the tendon The probe is drawn entirely through, leaving the guide-suture in place

3 The third skin incision is made over the peroneus longus tendon from the middle of the calf to the cuboid The upper end of the incision curves anteriorly The skin and subcutaneous tissues above the malleolus are retracted from the underlying fascia until not only the peroneal muscles, but also the extensor muscles are visible

4 The fascial plastic The fascia is carefully incised first over the peroneal compartment, then over the anterior muscular compartment This latter incision is made to outline a flap which is inverted so as to expose the paratenon clothing its deep surface and is sutured by a Lembert stitch to the edge of the inverted fascia of the lateral fascial compartment The stitch itself is taken as near as possible to the fibula so as to bury it in the muscular fibers of the peroneus brevis By this procedure a physiological path for the peroneal tendon is constructed

5 An eye-probe is then passed from the upper pole of the tibialis sheath beneath the fascia cruris and made to appear in the region of the fascial plastic The upper end of the guide suture lying in the tibialis sheath is drawn beneath the fascia by means of the probe

The guide suture thus runs from the fascial plastic beneath the fascia cruris into the tibialis anticus sheath, downward through the sheath and out near the insertion of the tibialis tendon. It serves to draw the peroneal tendon along this course.

6. The peroneal tendon is now freed by prolonging the fascial incision already made over its upper end, downward until the sheath has been opened, usually 3 to 4 cm. above the malleolus, and then along the sheath to the groove in the cuboid where the peroneal tendon passes into the sole of the foot. When the peroneal tendon is divided at this point, it reaches exactly the desired insertion on the inner border of the foot. It is threaded with the fixation suture, freed from its mesotenon. and, by means of the guide suture, drawn over the fascial bridge downward through the tibialis sheath, fixation to the dorsum of the internal cuneiform is accomplished. The fascial incisions are closed wherever possible.

The following operations are called physiological by Mayer:

Foot.—1. For talipes valgus: (*a*) Extensor proprius hallucis through the sheath of the tibialis anticus or transplanted with the sheath to the inner border of the foot. (*b*) Peroneus longus through the sheath of the tibialis anticus. A and *b* can be combined; the peroneal tendon is run through the tibial sheath; the extensor hallucis tendon is transplanted with its sheath. (*c*) The extensor longus digitorum and the peroneus tertius are directed subcutaneously to the inner border of the foot. (*d*) The flexor longus digitorum is passed through the sheath of the tibialis posticus and inserted into the scaphoid. The flexor digitorum is in its original situation a supinator and an abductor, but transferring its insertion to the scaphoid increases this action and helps to maintain the normal contour of the foot.

2. For talipes varus: (*a*) The tibialis anticus is passed through the sheath of the extensor longus digitorum and peroneus tertius to the cuboid or to the base of the fifth metatarsal bone. (*b*) The extensor proprius hallucis is passed through the sheath of the peroneus brevis to the fifth metatarsal.

3. For talipes calcaneus: (*a*) The flexor longus hallucis is attached to the tuberosity of the os calcis. (*b*) The peroneus longus is secured to the tuberosity of the os calcis. A and *b* may be performed at the same time. When the talipes calcaneus is combined with marked cavus deformity, a preliminary astragalectomy is advisable.

4. For talipes equinus: (*a*) Transplantation of the peroneus longus through the tibialis anticus sheath to the internal cuneiform. (*b*) Transplantation of the peroneus brevis subcutaneously to the base of the fourth metatarsal. A and *b* are always performed together.

5. Claw-toe: Jones' operation of inserting the long extensor into

the head of the metatarsal bone meets the physiological requirements Lambrinudi's operation is highly regarded

Tenodesis —Tenodesis is tendon fixation The anchorage of paralyzed tendons into grooves in bone was popularized by Gallie The method consists chiefly in turning up an osteoperiosteal flap, suturing the tendon into the groove, and replacing the flap A paralyzed tendon sutured into bone is prone to stretch and permit recurrence of the deformity It must be maintained in the proper position for a suffi-

Fig 291 —Arthrodesis fusion of ankle

ciently long time Foot-drop may be controlled by anchoring the extensor tendons into the anterior surface of the tibia Gallie's tenosuspension operation for equinus is excellent though complicated and difficult Varus may be corrected by anchoring the peroneals into the fibula, and valgus by anchoring the tibialis posticus into the tibia Calcaneus can be controlled by suturing the gastrocnemius as a ligament into the posterior surface of the tibia

Muscle Transplantation —Muscle transplantation is not practical

Silk Ligament Suspension.—Silk ligament suspension was popularized by Lange. The principle of the operation is that a silk ligament, when used as a substitute for a tendon, forms a nucleus for connective tissue and acts as a new ligament. The silk must be specially prepared. Lange encloses it in parchment paper.

Fascial Transplants.—The use of fascial transplants for fascial suspension is more scientific than the use of silk ligaments for that purpose. The fascia is usually obtained from the lateral margin of the thigh.

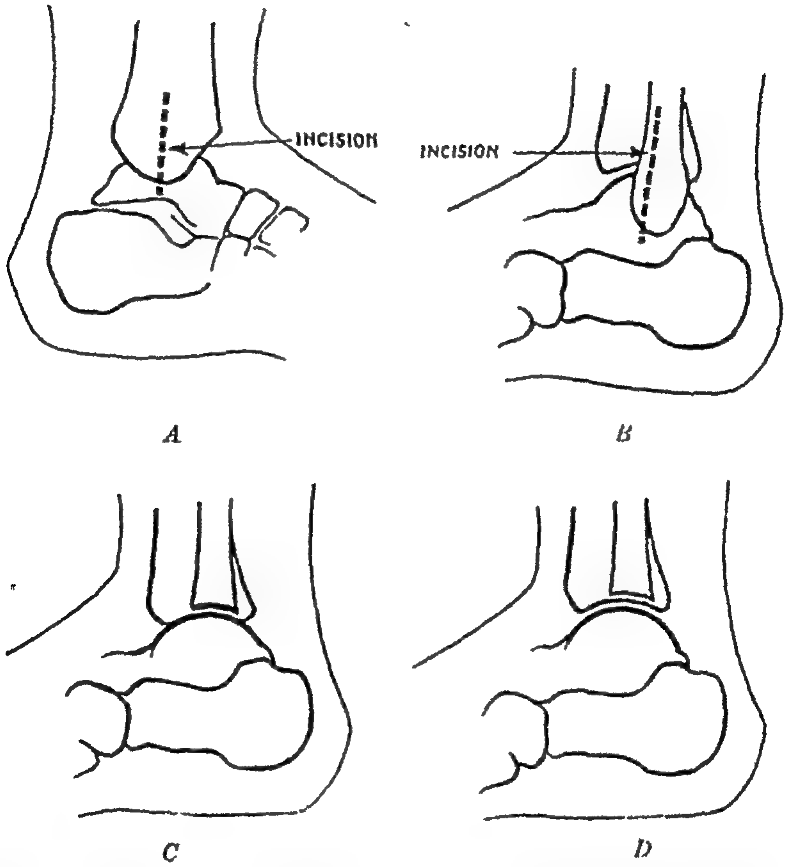


FIG. 295.—*A*, Through a medial skin incision, the medial malleolus is subperiosteally resected. The malleolus may be discarded or may be cut up into small pieces and later used as grafts. *B*, Through a lateral incision, the lateral malleolus is also subperiosteally resected. If indicated, this malleolus may be likewise utilized. *C*, The resected ankle exposed. *D*, Since the curve of the contacting surfaces corresponds to that of the ankle joint, contact is complete, regardless of the degree of equinus. (Roger Anderson, courtesy of Jour. Bone and Joint Surg.)

Operations on Bones.—*Operations on bones include osteotomy, tendon fixation, arthrodesis, bone lengthening, and bone shortening.*

Arthrodesis.—"Arthrodesis" means making a joint immovable by fusion or consolidation of its bony component parts. The applications of arthrodesis are among the triumphs of orthopædic surgery. The concept of stiffening joints originated with Albert in 1878. The indications are to correct deformity and provide stability.

The most important operations for arthrodesis of bones of the feet are the triple arthrodesis of Ryerson, the subastragalar arthrodesis of Hibbs and Dunn, the operation designed by Hoke and the panastragalar arthrodesis of Goldthwait, Albee, and Steindler. The subastragalar arthrodesis is used as a standard operation. Modifications of its general technic are made to meet special requirements.

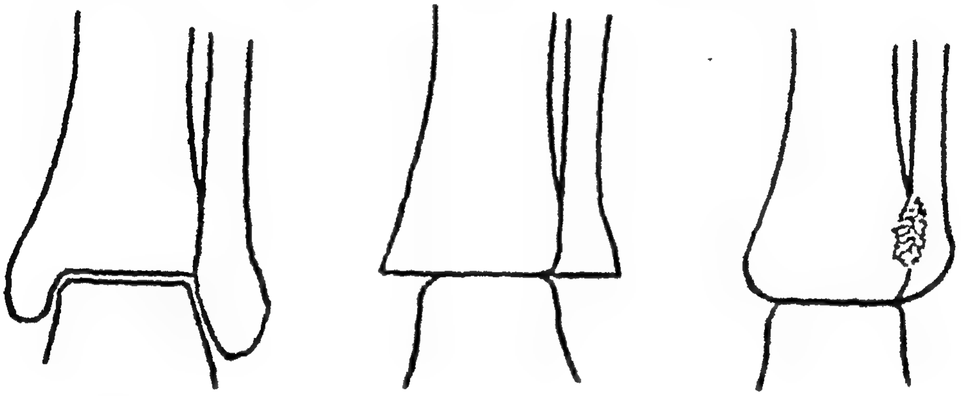
The principles of arthrodesis demand: (1) accurate approximation of the bones, like the "fit" of the cabinet maker, (2) proper relationship of portions of the extremity to each other, and (3) retention in proper position until consolidation is complete. The contraindications are youth and an insufficient lapse of time after an acute attack of poliomyelitis. Arthrodesis is especially valuable in the foot and ankle.

FIG 296.—Thin osteotome, the curve of which corresponds to the arc of the ankle joint. The two widths are illustrated in the foreview. The curve of the osteotome corresponds to the arc of a circle which has a diameter of 3.8 cm. (1½ inches). (Roger Anderson, courtesy of Jour. Bone and Joint Surg.)

Arthrodesis of the Foot in Poliomyelitis.—The originator of arthrodesis was Albert, of Vienna, who in 1878 curetted the joint surfaces of the tibiotarsal articulation in a case of paralytic pes equinus. Whitman, in 1901, first introduced the fundamental principle of posterior displacement of the foot to gain bone balance. Arthrodesis of the subastragalar joint was originally advised and performed by Nieny in 1905. Davis, in 1913, was the first to combine the procedures of subastragalar arthrodesis and posterior displacement of the foot. Davis first emphasized the physiological unity of the subastragalar joint which includes two separate anatomical articular entities, the calcaneocuboid and astragalo-scaphoid articulations. Hoke, in 1921, and Dunn, in 1922, introduced the principle of removing bone between the cuneiform bones anteriorly and the body of the astragalus posteriorly to produce posterior displacement of the entire foot in relation to the leg and ankle joint. Ryerson, in 1913, recognized that calcaneo-cuboid fusion should be added to subastragalar fusion if the entire physiological unit involved in lateral deformities of the foot was to be completely stabilized. The term "triple arthrodesis" refers to fusion of the three distinct anatomical entities which form the physiological unit included in lateral movements and deformities of the foot. The three anatomical entities are the calcaneo-astragalar, calcaneo-astragalo-scaphoid, and calcaneo-cuboid joints. The first and second form the subastragalar joint as defined by Davis. There should be no confusion regarding the terms

'subastragalar' and 'triple.' These principles form the basis of the refined methods universally employed for stabilizing paralytic talipes and they may be judiciously supplemented by tenotomy, osteotomy, fasciotomy, tenodesis, tendon transplantation, tarsectomy, and bone block procedures.

Operations on the Ankle Region.—Operations on the ankle region include those on the ankle and those on the Achilles tendon.



A *B* *C*

FIG. 297.—*A*, The relationship at the ankle joint before resection. *B*, Subperiosteal resection of the malleoli produces an apparent broadening of the ankle. *C*, The bases of the malleoli are reshaped, as illustrated. Excess bone may be placed around the ankle joint in the form of small grafts. Prominence of the anterior and posterior margins of the tibia may be similarly treated. Through the lateral incision, synostosis is produced on the anterior side between the fibula and tibia. (Roger Anderson, courtesy of *Jour. Bone and Joint Surg.*)

Achilles Tendon.—The chief operations on the tendon of Achilles are lengthening and shortening operations. Lengthening is performed in several ways. The simplest method is direct division of the tendon. This operation should be performed only on very young children. For others, some type of plastic operation is preferred.

Dunn finds that slight shortening of the tendon of Achilles may be of advantage in poliomyelitis. For example, when it is done in cases of quadriceps insufficiency, the strain on the gastrocnemius muscle produced by weight-bearing locks the knee joint, thereby increasing its stability. In cases of simple cavus deformity a shortened Achilles tendon acts as an anchor which allows correction of deformity. In extreme equinus, lengthening of the tendon of Achilles may be necessary to allow relaxation and recovery of the weakened anterior tibial group of muscles. The lengthening should be sufficient to allow the right-angled position of the foot.

The simplest method of shortening the Achilles tendon is a step-like plastic operation with removal of the desired amount of the tendon.

Ankle.—The chief operation on the ankle joint is arthrodesis. The first arthrodesis on the ankle was performed over sixty years ago by

Albert, who curetted the joint surfaces of the astragalus and tibia and "fixed" the foot at a right angle

Panastragalar arthrodesis Panastragalar arthrodesis is fusion of all of the articular surfaces contacting the astragalus It was devised independently by Goldthwait, Albee, and Steindler It is of value in cases of flail ankle joint, *i e*, dangle-foot, with weakness of the quadriceps extensor, since with a slight equinus position the knee joint is locked as the patient walks Steindler puts the foot up in 20 degrees of plantar flexion He finds that a flail foot not deformed and associated with a good knee, or at least with good or fair knee flexors, is best suited for this operation

In cases of dangle-foot, Morrison and MacKenzie apply two osteoperiosteal grafts to the back of the foot and lower leg and suture them to the denuded periosteum of these structures Cramer uses a periosteal bone flap on the anterior surface of the tibia to bridge the ankle joint in front

Operations for Deformities of the Foot —Before advising treatment it is necessary to determine the cause of the deformity, the degree of power present in the muscles, and the potentialities for recovery of the muscles The deformity may be postural or due to unbalanced muscular control of the foot increased by the body weight It is in some of the more extreme deformities that the surgeon is most successful in improving function

In certain cases, arthrodesis of the ankle may be necessary to secure stability Whitman's astragalectomy should be reserved as an alternative operation for cases of complete paralysis with lateral instability and cases of calcaneo-cavus in which the posterior tibial and peroneal muscles as well as the calf muscles are paralyzed

The human foot is adapted for support and locomotion The most important movement is propulsion of the body by controlled flexion and extension at the ankle Therefore, it is important to preserve these movements at the ankle if possible This can be done by sacrificing the mid-tarsal and subastragalar joints Bony union of these joints insures stability of the foot, leaving such muscle power as is present for control of the ankle movements Lambrinudi performs a subastragalar arthrodesis and does a step operation on the astragalus and os calcis

Hoke employs his stabilization operation, the fundamental basis of all surgical procedures for paralytic feet with marked architectural deformity and loss of muscle power, because he believes that a stable skeletal foundation is imperative

The patient with a bad paralytic deformity of the foot, walks worse than the person with an artificial limb Motion between the foot and leg is a compound of motion at three joints namely, the ankle joint,

the subastragalar joint, and the astragalo-scaphoid joint. For good function it is necessary to preserve the ankle joint motion. For architectural reasons it is necessary for the articulation to be intact at bearing points between the astragalus, tibia, and fibula. The sub-astragalar and the astragalo-scaphoid joints must be stabilized.

Hoke says feet that have been operated upon should look natural in shoes; should be so stable that they will not turn laterally on the long axis of the foot when the patient is standing and walking; should be so stable in the natural attitude that they will not need braces to hold them; and, when barefoot, should look natural or at least present no gross deformity.

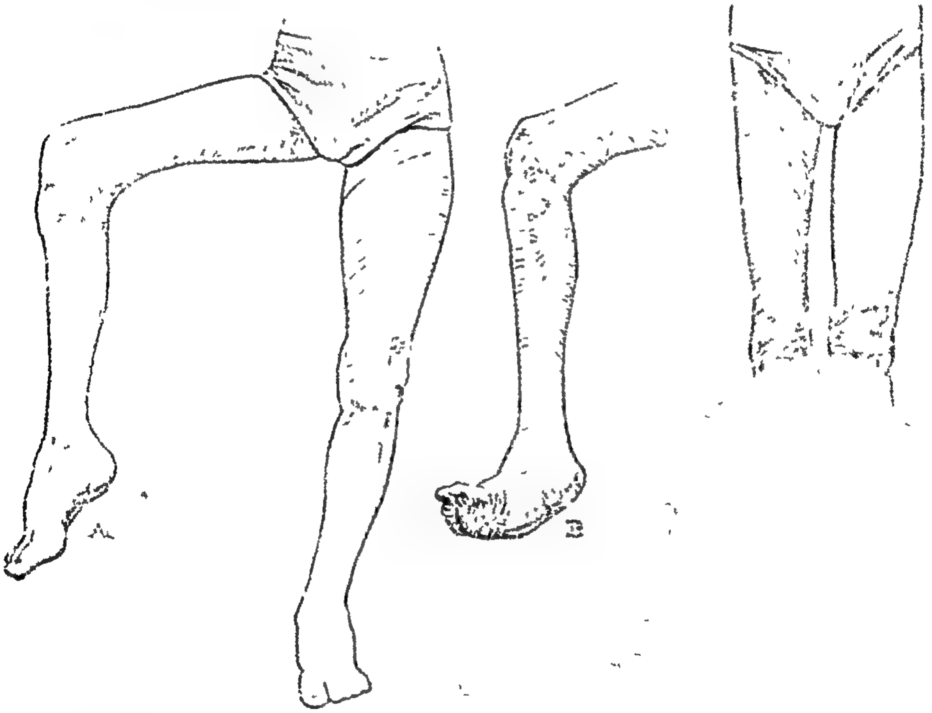


FIG. 208 —Talipes equinovarus due t... tion and external rotation in order to ... corrected by Hoke operation on foot

The differences in his operat... the astragalus is treated. Thi... foot, in another for flat-foot. Hoke therefore has a drop-foo... stabilization.

The chief tendon transplantati... of the tibials to assume the fu... transference of the extensor hal... cated by Gallie; and the Whitm... tendon transplantations should ...

arthrodesis Other operations are tendon lengthening, fasciotomy, and capsulotomy

Simple Varus Deformity—The removal of bone and division of ligaments should permit correction of adduction at the mid-tarsus and of varus of the heel

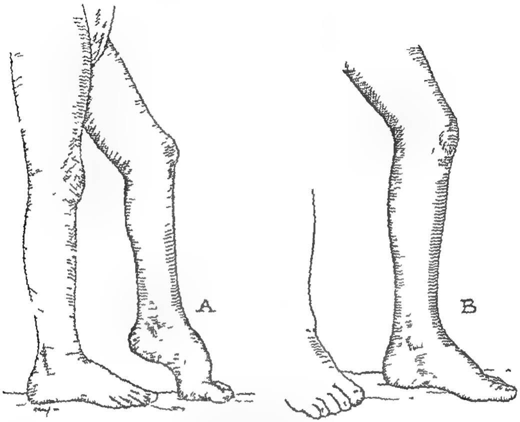


FIG 299—Left spastic monoplegia corrected by Hoke stabilization operation (Drawn from photographs)

Equinus—In cases of paralytic equinus in which there are two strong peroneal tendons, Dunn transplants them to the dorsum of the foot, the longus to the inner, the brevis to the outer side This operation combined with triple arthrodesis results in a stable foot which has good dorsal and plantar movements In cases in which the peroneal tendons are not available, the best method is a Campbell bone block

In 1919, Toupet performed an astragalar arthrodesis by means of a graft transfixing the astragalus to the calcaneus and allowing the posterior extremity to project behind as a prop against the tibia to prevent drop-foot Later, Putti introduced an anterior prop to prevent calcaneus In 1923, Campbell introduced the bone-block method, and, in 1925 Nové-Josserand presented another modification

In the anterior "*artrorise*" of Putti the neck of the astragalus is

the subastragalar joint, and the astragalo-scaphoid joint. For good function it is necessary to preserve the ankle joint motion. For architectural reasons it is necessary for the articulation to be intact at bearing points between the astragalus, tibia, and fibula. The subastragalar and the astragalo-scaphoid joints must be stabilized.

Hoke says feet that have been operated upon should look natural in shoes; should be so stable that they will not turn laterally on the long axis of the foot when the patient is standing and walking; should be so stable in the natural attitude that they will not need braces to hold them; and, when barefoot, should look natural or at least present no gross deformity.

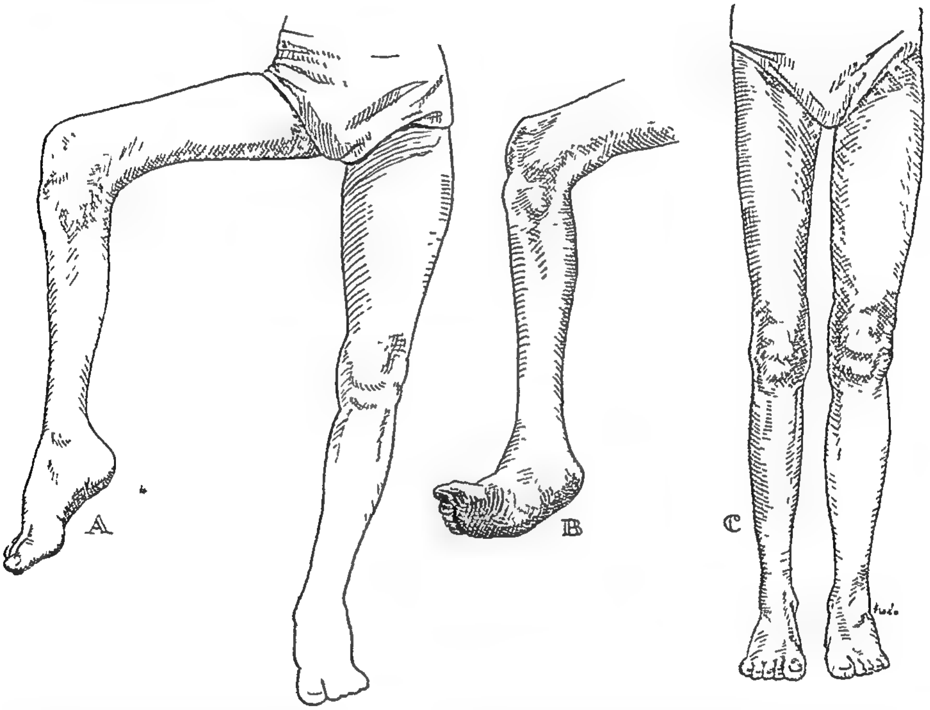


FIG 298.—Talipes equinovarus due to poliomyelitis producing a bizarre gait, abduction and external rotation in order to place sole of foot on the ground Completely corrected by Hoke operation on foot (Drawn from photographs)

The differences in his operations lie mainly in the way the head of the astragalus is treated. This is replaced in one position for drop-foot, in another for flat-foot, in another for club-foot, and so on. Hoke therefore has a drop-foot, a flat-foot, and a club-foot type of stabilization.

The chief tendon transplantations in the foot and leg are transference of the tibials to assume the function of the peroneals or *vice versa;* transference of the extensor hallucis longus; various tenodeses advocated by Gallie; and the Whitman loop operation. It is agreed that tendon transplantations should be supplemented by some form of

arthrodesis Other operations are tendon lengthening, fasciotomy, and capsulotomy

Simple Varus Deformity —The removal of bone and division of ligaments should permit correction of adduction at the mid-tarsus and of varus of the heel

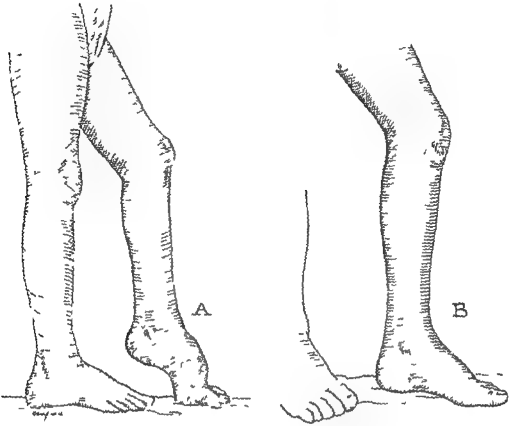


FIG 299 —Left spastic monoplegia corrected by Hoke stabilization operation (Drawn from photographs)

Equinus —In cases of paralytic equinus in which there are two strong peroneal tendons, Dunn transplants them to the dorsum of the foot, the longus to the inner, the brevis to the outer side This operation combined with triple arthrodesis results in a stable foot which has good dorsal and plantar movements In cases in which the peroneal tendons are not available, the best method is a Campbell bone block

In 1919, Toupet performed an astragalar arthrodesis by means of a graft, transfixing the astragalus to the calcaneus and allowing the posterior extremity to project behind as a prop against the tibia to prevent drop-foot Later, Putti introduced an anterior prop to prevent calcaneus In 1923, Campbell introduced the bone-block method, and in 1925, Nové-Josserand presented another modification

In the anterior "*artrorise*" of Putti the neck of the astragalus is

exposed by a longitudinal incision and the foot is placed in extension. A transverse opening is then made with a chisel at the level of the anterior border of the trochlea of the astragalus, and into this a tibial graft is sunk.

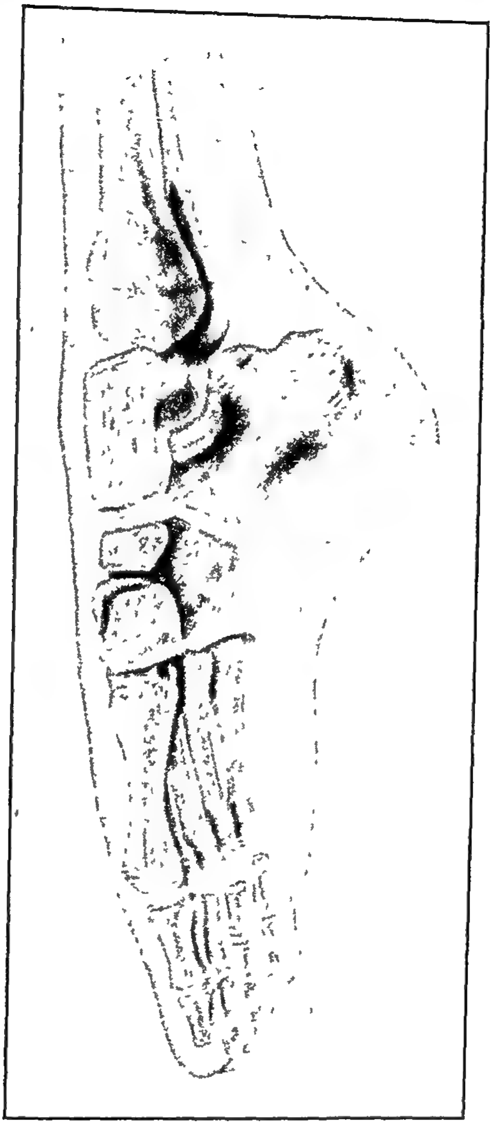


FIG 300 —Bones of foot and ankle in case of talipes equinus. (Courtesy of Dr Michael Hoke)

LAMBRINUDI OPERATION FOR DROP-FOOT

Principle of the Operation.—The normal locking of the ankle-joint in full equinus is produced by the posterior tubercle of the astragalus coming in contact with the posterior margin of the articular surface of the tibia, both covered by cartilage. This is a natural bone-block and more effective than any bone-graft. Consequently if the ankle-joint remained locked in full equinus, and the correction were made for the deformity at the joint below, the foot could not drop any further.

Description of the Operation.—A J-shaped incision is made, starting 4 inches above the external malleolus, close to the posterior margin of the fibula, carried down below the external malleolus, and ending at the center of the middle metatarsal bone. The skin, together with all the soft parts right down to periosteum, is dissected back *en masse* so as to expose the front and back of the ankle, great care being taken to leave intact the anterior and posterior ligaments of the ankle-joint itself. *The peronei are divided low down and dissected up.* The astragalo-scaphoid joint is next sought for, opened, and the knife is carried under the head and neck of the astragalus into the front part of the subastragaloid joint. The interosseous ligament is then divided, and the knife carried into the posterior compartment of that joint.

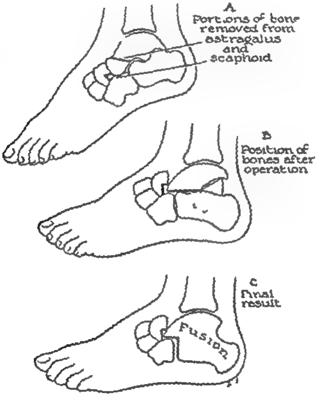


Fig. 301.—Lambrinudi operation to correct paralytic equinus. (Courtesy of Brit. Jour. Surg.)

The subastragaloid joint is now sufficiently freed to allow the foot to be dislocated inwards, leaving the astragalus *in situ*. In order to mobilize the foot a little more, the soft parts are dissected away from the inner side of the calcis and the lower articular surface of the astragalus, and a notch is made horizontally from side to side in the postero-inferior aspect of the scaphoid. Then the head of the astragalus is depressed to its utmost limit and the neck is sawn through in the direction of the black line as shown in Figure 302. The foot is next dorsiflexed, so that the cut surface of the neck of the astragalus lies on the upper surface of the os calcis, and the sharp anterior margins

fit into the notch made in the scaphoid. The obliquity of the sawcut through the neck of the astragalus depends upon the angle at which it is desired to set the foot. If the paralysis is complete, the foot should be set at any angle of 95 degrees to the leg; if it is incomplete, it should be set in varying degrees of equinus, so that whatever power remains can be employed over a more useful range.

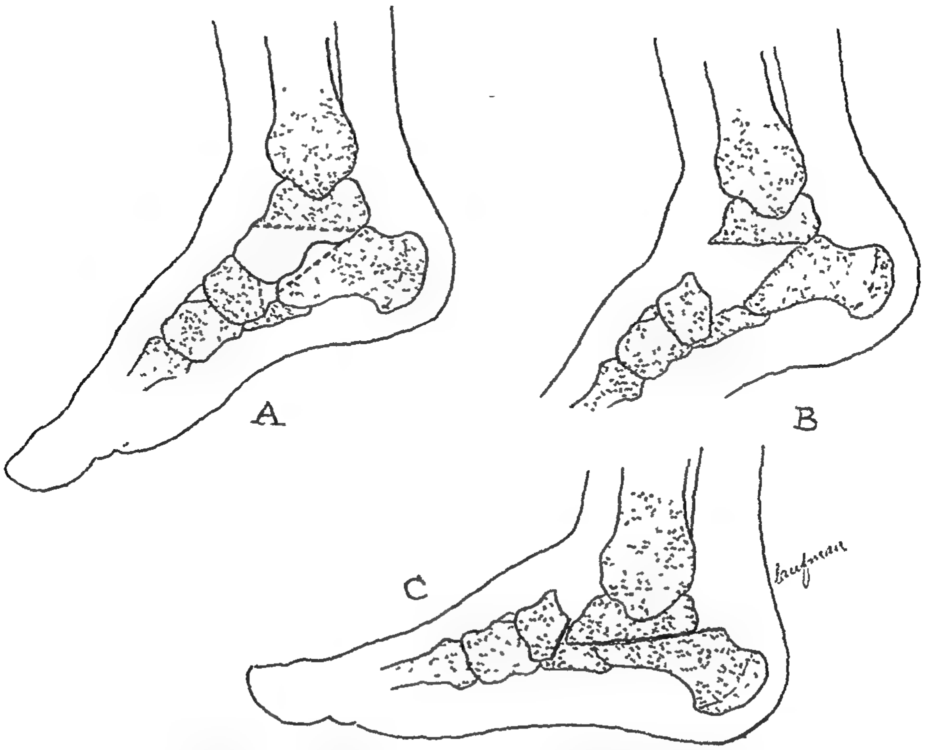


FIG. 302.—A method of correcting equinus and calcaneus deformities of the subastragalar joint Redrawn from Lambrinudi. (Lambrinudi, Section of Orthopædics, Proceedings of the Royal Society of Medicine, 26, 788, 1932)

The angle produced between the articular surfaces of the os calcis and the astragalus, both denuded of their cartilage, is now filled up by a graft taken from the excised head and neck of the astragalus. This graft is not intended to act either as an intra- or extra-articular block, but is designed merely to increase the anterio-posterior thickness of the astragalus when placed in this practically vertical position.

The foot is set at an angle of 95 degrees to the leg and cannot drop because the ankle-joint is locked in full equinus.

1. This operation can control a drop-foot even though the gastrocnemius is active and powerful.
2. It permits of a certain range of movement at the ankle joint enabling the gastrocnemius to come into action, assisting an important phase of the step forward, and at the same time keeping the foot up sufficiently for it to clear the ground.
3. Only one joint is arthrodesed—the subastragaloid.

Patients with equinus are undoubtedly better on their toes with straight knees than on their heels with crooked knees and calcaneus deformity

Campbell's Bone-block Operation —Campbell's bone-block or check operation for equinus deformity consists in building up bone onto the

Fig 303 —Poliomyelitic paralytic foot before operation Note positions of and wide spaces between tarsal bones

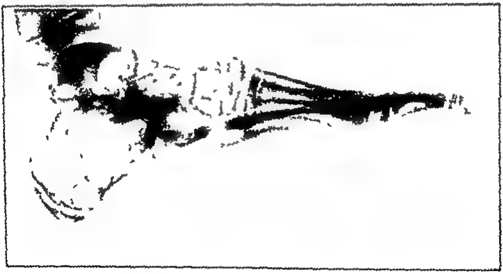


Fig 304 —Poliomyelitic paralytic foot after Hoke arthrodesis Same patient as shown in figure 303

denuded posterior portion of the os calcis When this is done, the built-up bone, which projects upward, butts against the posterior portion of the tibia, thereby producing a block when the foot is forced into equinus The mechanism is similar to that of hyperextension block by the olecranon In Campbell's series of over 350 cases, the

results have been excellent. When indicated, the operation may be performed on patients over eight years of age.

The technic is as follows: The skin incision is made over the Achilles tendon if this structure is contracted; otherwise, at either side. It extends from the superior aspect of the tuberosity of the os calcis upward for 3 or 4 inches in a straight line. If the tendon of Achilles is contracted, a plastic lengthening is performed. A straight incision is then made in the mid-line to the posterior portion of the ankle joint, and the tendon of the flexor longus pollicis is retracted inward. To expose the posterior surface of the os calcis, a pyramidal space is cleared with a heavy periosteal elevator. The posterior extremity of the astragalus and the posterior portion of the articular surface of the

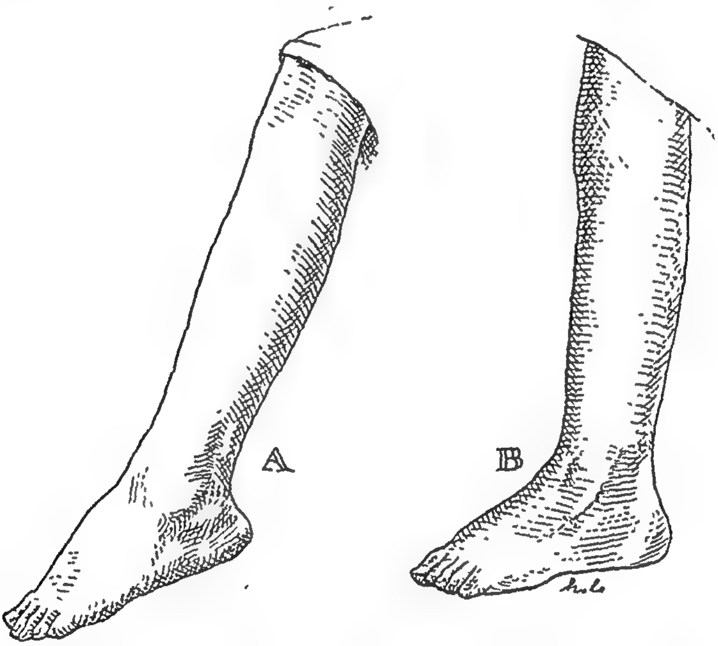


Fig. 305.—Talipes equinus or drop-foot due to poliomyelitis. *A*, Before. *B*, After Operative correction by means of Campbell bone-block. (Drawn from photographs.)

tibia are then brought into view by dorsiflexing the foot. The posterior portion of the astragalus is removed with a curved chisel to permit close approximation of a graft and an intra-articular as well as an extra-articular block. The large graft is placed in a cavity made for it on the superior surface of the os calcis just posterior to the ankle joint. Bone is then transplanted from any portion of the skeleton. As it is usually necessary to enter the forefoot for stabilization by arthrodesis, the bone which is often excised in that procedure may be utilized as transplants. Although spongy bone adapts itself more naturally than dense bone from the tibia, Mayer has advocated a tibial transplant. If bone is excised from the forefoot, it is denuded of cartilage, a piece about $\frac{1}{2}$ by 1 inch in diameter is placed in the cavity prepared on the superior surface of the os calcis, and small particles of bone, "bone

hash," are arranged about it in pyramid formation The cartilage is removed and placed in mosaic fashion over the posterior, inner and outer aspects of the pyramid to prevent adhesion to surrounding structures The soft parts are sutured snugly to retain the transplants in position, the tendon of Achilles is united if its severance was required, and the fascia and skin are closed The foot is then held by

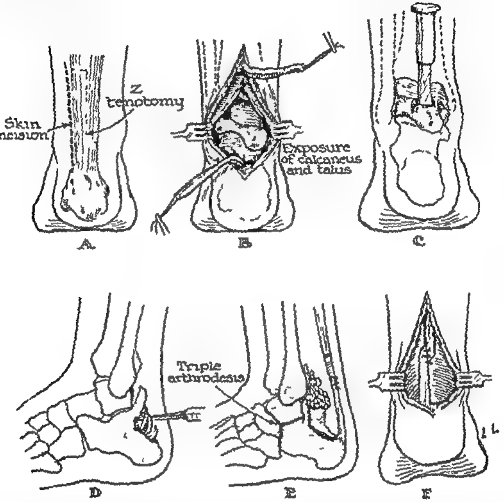


FIG 306 —Campbell's bone block operation for talipes equinus A Skin incision and tenotomy B Pyramidal space showing superior surface of the os calcis and posterior aspect of ankle joint C Large piece of bone selected to be placed on upper surface of os calcis D Side view showing bone-block in position approximate to and within ankle joint E indicates the bone block bone chips and arthrodesis of astragaloscaphoid subastragalar and calcaneo-cuboid joints F Final stage after lengthening and reuniting cut ends of Achilles tendon (After W C Campbell from Lewin's Infantile Paralysis W B Saunders Co)

a plaster cast at an angle of 90 degrees with the leg Overcorrection is to be avoided as it is preferable to secure a slight degree of plantar flexion in order to avoid a flat sole or heel walking The cast is removed at the end of eight weeks

Gill proposed a modified Campbell operation for paralytic foot-drop With the foot in extreme dorsiflexion, he turns up a flap with a very thin osteotome which he drives through the posterior portion of the

astragalus. Beneath this flap he inserts a wedge of bone taken from the os calcis just anterior to the attachment of the tendon of Achilles. He then taps the bone wedge into place, closes the wound, and puts the foot up in slight dorsiflexion.

Miltner recommended making a longitudinal cut in the lower fourth of the fibula and displacing the lower end of the posterior fragment of the fibula so that it will act as a block to prevent the equinus position of the os calcis. This procedure may be supplemented with arthrodesis of the tarsus and tenotomy of the tendo Achillis.

Putti favors the Gallie suspension operation for dropped forefoot, utilizing the extensor tendons as guy ropes. It is a more technical procedure. I have proposed turning down a flap from the posterior surface of the tibia.

Arthrodesing operations on the foot are performed to correct deformity, to stabilize the foot, to relieve pain, and to get rid of braces.

Davis Operation.—The subastragalar arthrodesis of Davis produced fusion of the astragalus, the os calcis, and the scaphoid. This was secured by digging up the joint surfaces thoroughly by means of gouges without removing any portions of bone from the wound.

Ryerson's Triple Arthrodesis.—An incision, begun just posterior to the inner malleolus and immediately below it, is carried directly over the astragalo-scaphoid articulation to a point at about the middle of the first metatarsal bone. Below the malleolus, the tendon of the tibialis posticus is identified, its sheath is opened, and the tendon is retracted upward to expose the joint at the sustentaculum tali between the astragalus and calcaneum. The posterior part of the subastragalar joint is exposed by further retraction backward. The articular cartilage is then removed with a narrow chisel or flat gouge, and the denudation completed with a very small and strong curette.

Next, the astragalo-scaphoid joint is opened. The attachments of the capsule and ligaments are "peeled away" with a chisel. The cartilage is then removed by means of osteotome and curette. The denudation must be thorough. In children six or seven years of age, the cartilage on the head of the astragalus is nearly $\frac{1}{4}$ inch thick, and by the time the bleeding bone of the ossification center is reached there is practically no possibility of bony contact between it and the denuded concave surface of the scaphoid. This is one of the chief reasons for not operating on young children and the most frequent cause of non-fusion in th[illegible] joint. In children ten years of age or older, the cartilage is th[illegible] resu[illegible]s are proportionately better with each additional [illegible] It is especially necessary to denude the latera[illegible] h great care so that when the calcaneo-cubc[illegible] denuded there will be a complete trans-[illegible] foot and the midtarsal joints will be

entirely denuded If any marked degree of varus or valgus is present, a wedge-shaped piece may be removed from the outer or inner section of the mid-tarsal joint to correct the deformity In cases of pes cavus or hollow claw-foot or calcaneus, the base of the wedge should be upward When there is deformity beyond the mid-tarsal joints the joints between the scaphoid, internal cuneiform and the base of the first metatarsal may be similarly denuded

An incision is now made on the lateral border of the foot It is begun just posterior to and below the external malleolus and extended distally to, or beyond, the base of the fifth metatarsal bone The sheath of the peroneus tendons is then opened and the tendons are retracted upward to expose the lateral portion of the substragalar joint This joint can usually be completely denuded with a chisel and small curette without cutting the external lateral ligamentous structures The substragalar joint with its two or three subdivisions is by far the most difficult joint of the foot to expose and prepare for fusion

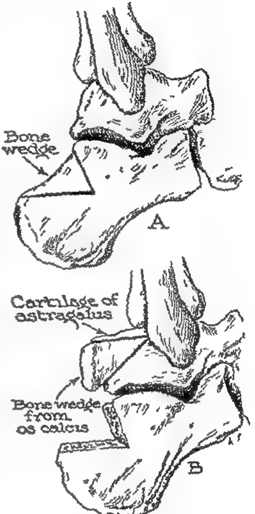


Fig 307 —Gill s bone-block operation to limit foot drop Bone wedge removed from os calcis and inserted into astragalus

After this has been done, the calcaneo-cuboid joint is denuded so that the foot is completely mobilized and freed throughout the whole extent of the mid-tarsal region Next, the metatarso-cuboid articulation is attacked and the cartilage cleaned out The foot as a whole is then viewed with regard to the complete correction of any preexisting deformity, and whatever remodelling is necessary, is done

Hibbs Operation —According to Smith and von Lackum, the Hibbs operation is based on the principle that the astragalus is the most stable bone in the foot and practically all lateral motion or deformity occurs in the substragalar and mid-tarsal joints Motion is eliminated in these joints by fixing the os calcis and scaphoid to the astragalus and the cuboid to the os calcis

As a rule two incisions are made, one over the inner side of the foot, commencing just below and in front of the medial malleolus and extending downward and forward across the astragalo-scaphoid joint, and the other extending forward from the tip of the lateral malleolus across the calcaneo-cuboid joint. The joints involved should be completely exposed before any cartilage is removed or any fitting together of the bones is attempted. The medial incision permits exposure not only of the head and neck of the astragalus and of the scaphoid, but also of the joint at the sustentaculum tali. In approaching the joints on the outer side of the foot, it is necessary to split and dissect aside the extensor digitorum brevis. This exposes the calcaneo-cuboid joint and the promontory on the anterior aspect of the os calcis. Just

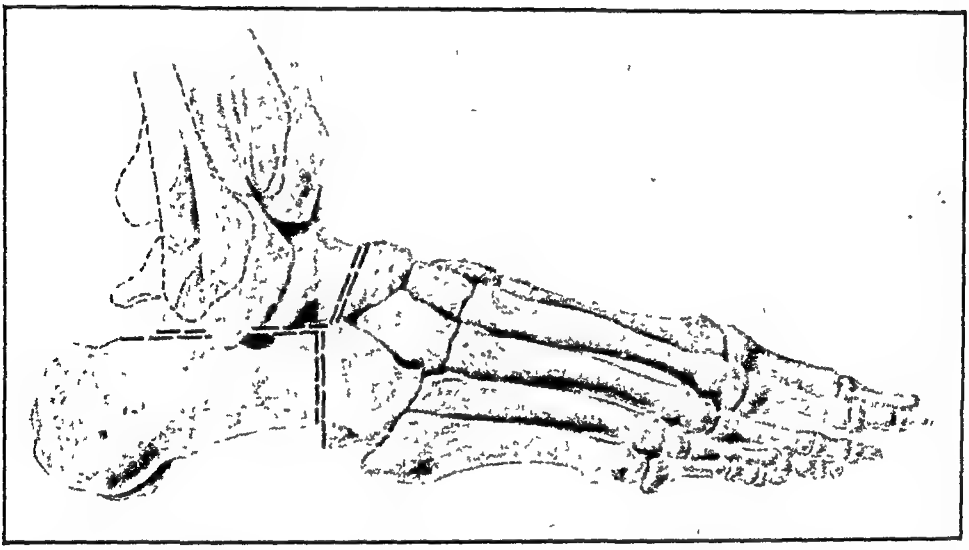


FIG. 308.—Diagram of result after three-joint type of arthrodesis. Original position of bones partially indicated by dotted lines. (Cole, courtesy of Jour Bone and Joint Surg.)

posterior to the promontory is the subastragalar fossa, which is filled with fat and several blood-vessels and surrounded by the thick, strong interosseous ligaments. At the back of the fossa are the anterior lips of the facets composing the large posterior part of the subastragalar joint. It is necessary to remove the ligaments, but care should be exercised to leave enough fat to prevent a dead space. After the exposure has been made, the cartilage is removed and the bony surfaces are fitted. The head and neck of the astragalus are removed by a transverse cut sloping backward. The amount of the head and neck excised depends partly upon the degree to which it is desired to displace the foot posteriorly. The articular cartilage and the upper portion of the bone of the scaphoid are removed in such a way that the cut surface faces backward and upward. This makes possible the sliding back of the scaphoid beneath the astragalus. The articular cartilage is also

removed from the joint at the sustentaculum through this medial incision In certain types of varus deformity it may be found easier to do the entire operation through the incision on the outer side of the foot Through the outer side the cartilage is removed from between the os calcis and the cuboid, but unless the forefoot is adducted it is unnecessary to remove any bone The subastragalar joint is now dealt with by leveling off the entire superior surface of the os calcis on one plane This necessitates cutting off the top of the anterior promontory and removing more than just the cartilage from the joint The cartilage and sufficient bone are removed from the inferior surface of the astragalus By fashioning the surfaces of the os calcis and astragalus, a varus, valgus, or calcaneus position of the os calcis can be corrected

It is of prime importance to set the foot backward beneath the astragalus If this is not done, the weight-bearing line will come through the posterior part of the foot and the strain will not be well distributed on the longitudinal arch Under such conditions there will be a lateral strain on the foot which is liable to stretch the lateral ligaments and produce instability

It can be demonstrated by roentgenograms of calcaneus feet that the os calcis is deformed, the bone itself pointing downward rather than being simply rotated because of dorsiflexion of the foot It is necessary to overcome this condition by removing a wedge, with its base posterior, from the subastragalar joint This permits the heel to be brought upward as well as backward To get the os calcis far enough back, the lateral ligaments must be detached subperiosteally from it As good bone contact can be obtained, there is no longer any hesitation about operating on children of a minimum age of six or seven years, if the deformity cannot be controlled otherwise It is preferable, however to wait until the age of nine or ten years

Supplementary procedures may be indicated such as lengthening of the tendon of Achilles, division or lengthening of the tibialis posticus and release of the internal lateral ligaments of the foot, fixation of half of the Achilles tendon in the tibia, release of the plantar structures, and transplantation of the extensor hallucis longus into the scaphoid

Smith and von Lackum emphasize that subastragalar arthrodesis demands surgical skill and experience as well as meticulous after-care The foot must be displaced backward beneath the astragalus and fixed in a neutral lateral position

In the majority of cases the astragalus is stable In the few in which it is not stable, subastragalar arthrodesis can be done successfully provided the foot is well placed laterally and anteroposteriorly The operation is adapted to nearly every type of foot deformity In the cases in which it was performed by Smith and von Lackum, the best

results were in the calcaneus feet. One must be careful not to cut the posterior tibial artery.

Dunn's Operation.—Dunn divides the foot into three sections: (1) the astragalus and bones of the leg, (2) the os calcis, and (3) the forepart of the foot. He considers the removal of bone to correct deformity and insure ankylosis of these joints in a good weight-bearing position to be only a "matter of careful carpentry." If necessary, the foot may be displaced backward in its relation to the astragalus.

In Dunn's technic, an incision is made from just in front of and above the external malleolus to the dorsal surface of the base of the fifth metatarsal bone. The outer border of the extensor brevis digitorum muscle is exposed and its origin from the head of the os calcis is

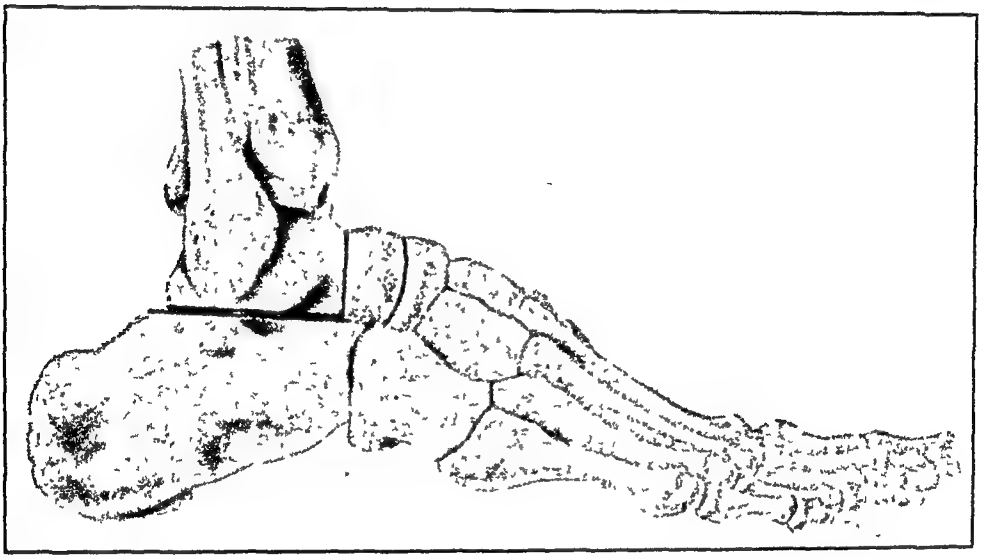


Fig. 309.—Diagram of result after Hoke type of arthrodesis showing remodeled astragalar head in position. (Cole, courtesy of Jour. Bone and Joint Surg.)

divided. By its reflection with the tendons of the anterior tibial group of muscles toward the inner side of the foot, the entire dorsal surfaces of the tarsal bones are freely exposed. If necessary, the Achilles tendon is elongated just sufficiently to allow the normal range of movement of the ankle. By means of an osteotome, a portion of bone including the articular surfaces of the os calcis and cuboid is removed. The amount of bone removed will determine the result and the shortening of the foot. The head of the astragalus is divided just behind the level of its articular cartilage. The proximal cartilage of the cuneiform bones is next removed, so that the bone removed from the inner side of the arch of the foot includes the articular cartilage of the head of the astragalus, all of the scaphoid and the adjacent cartilage of the cuneiform bones. The complete removal of the scaphoid may present some difficulty because of the numerous muscular and liga-

mentous attachments of this bone, but is important because incomplete removal will give the appearance of flat-foot after the foot has been shortened

A cup-shaped depression is cut from the dorsal surface of the cuneiform bones for the reception of the under surface of the head of the astragalus The strong interosseous ligament between the astragalus and os calcis is divided, and while the two bones are levered apart, the opposing cartilaginous surfaces are removed by means of a gouge The foot is then displaced backward at the subastragalar joint This allows the head of the astragalus to rest in the depression cut for it on

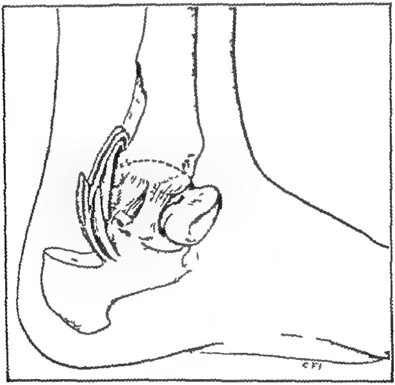


FIG 310 —*Posterior extra articular arthrodesis of ankle* (*Campbell Operative Orthopedics courtesy of The C V Mosby Company*)

the dorsal surface of the cuneiform bones, while the raw surfaces of the cuboid and os calcis are also in apposition The extensor brevis digitorum is replaced by a continuous catgut suture, and the wound closed Fixation in plaster-of-Paris completes the operation Dunn performs the operation on children of any age

Hoke's Operation —*In this operation,* which can be performed on children six years of age or older, the skin incision extends from over the external portion of the head of the astragalus downward and backward to the peroneal tendons below the end of the fibula The steps of the procedure are as follows (1) The subastragalar fossa is completely denuded of all tissue (2) The astragalo-scaphoid liga-

ment is cut. (3) A portion of the inferior surface of the body of the astragalus is removed. (4) A portion of the adjacent surface of the os calcis is removed. (5) The neck of the astragalus is cut through where it joins the body. (6) The amputated head and neck of the astragalus are grasped with sharp-pronged forceps. (7) The head of the astragalus is partly levered out, and the remaining attachments are cut with scissors. (8) The neck and head of the astragalus are placed in a towel and laid on the instrument table. (9) The cartilaginous facet of the superior surface of the os calcis is denuded with a small chisel. (10) The foot is shifted backward. (11) The head and neck of the astrag-

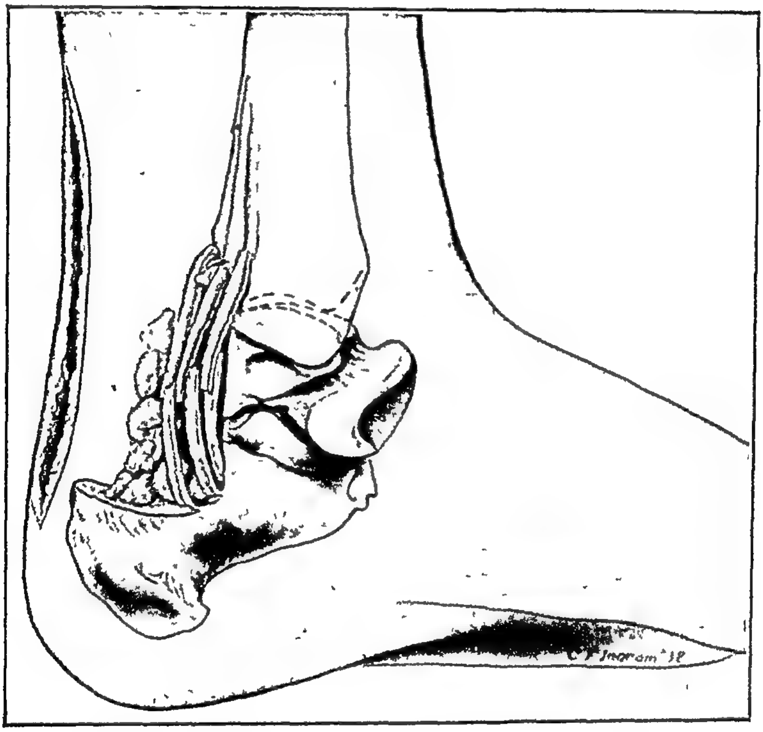


FIG. 311.—Posterior intra-articular arthrodesis of ankle and subastragalar joints. (Campbell, Operative Orthopedics, courtesy of The C. V Mosby Company.)

alus which were removed are held in forceps, and the cartilage on the head is shaved off with a knife just to the bone beneath. (12) The piece constituting the head and neck is trimmed down so that, when replaced, it will nestle between the scaphoid and the body of the astragalus without obstructing the "cocking-up" of the anterior portion of the foot. (13) The astragalus is sunk below the upper surface of the os calcis, and from this point on the foot is held by the operator until the plaster is set. (14) The assistant approximates the subcutaneous tissues with No. 1 catgut sutures while the skin is closed with interrupted silk sutures. (15) Plaster is applied up to the knee.

Brewster produced arthrodesis at the astragalo-calcaneal joint by means of a bone block made by trimming the astragalus and countersinking a portion of it into the os calcis This procedure prevents rocking of the foot in any direction In over 200 cases Brewster found that it eliminates the necessity of doing a bone block of the posterior portion of the joint in cases of drop-foot

Girard described a plastic operation of a somewhat similar nature Lambrinudi's operation is shown in Figures 301 and 302

TRANSLOCATION OF PERONEUS LONGUS TENDON

Transposition of peroneus longus tendon in calcaneal deformities of the foot has produced satisfactory results in a sufficient number of cases to warrant a continuation of its use The best results have been obtained when the operation was done on patients who had slight remaining power in the gastrocnemius muscle and fair or better power in the transposed peroneal muscle Bickel and Moe found that the results are strikingly better than if the peroneal tendon is cut and transplanted into the tendo Achillis or calcaneus

Operative Procedures —After sterile preparation and draping, a tourniquet is applied to the thigh A curved incision is made over the course of the peroneal tendons extending from about 2 inches (5 cm) above the lateral malleolus, around this structure and to the point where the peroneus longus passes beneath the tarsal bones to its insertion on the lateral aspect of the base of the first metatarsal and the infero-lateral aspect of the first cuneiform bone The peroneal retinaculum is split and the peroneus longus tendon is mobilized A second longitudinal incision is made around the apex of the heel in the mid-line and extending down to the periosteum This incision is then connected with the first by deep subcutaneous dissection (Fig 312) With a wide osteotome a V-shaped groove is cut into the calcaneus over its apex for about 1 inch (2 5 cm) This groove must be deep enough to receive the peroneal tendon (Fig 312) With an ordinary button-hook inserted in the second incision the peroneus longus tendon is pulled around into this new sulcus Extreme plantar flexion of the ankle and foot aids in this maneuver The tendon is inspected through the first incision and it is made certain that the plantar dissection has extended far enough medially to allow the tendon as direct a pull as possible in its new bed across the apex of the heel (Fig 312)

The superior and inferior peroneal retinacula may then be repaired with a continuous suture or a few interrupted sutures of chromic catgut Subcutaneous tissue is closed with interrupted plain catgut and the skin with plain interrupted zytor sutures A padded cast is applied from the toes to the knee with the ankle in about 45 degrees of plantar flexion

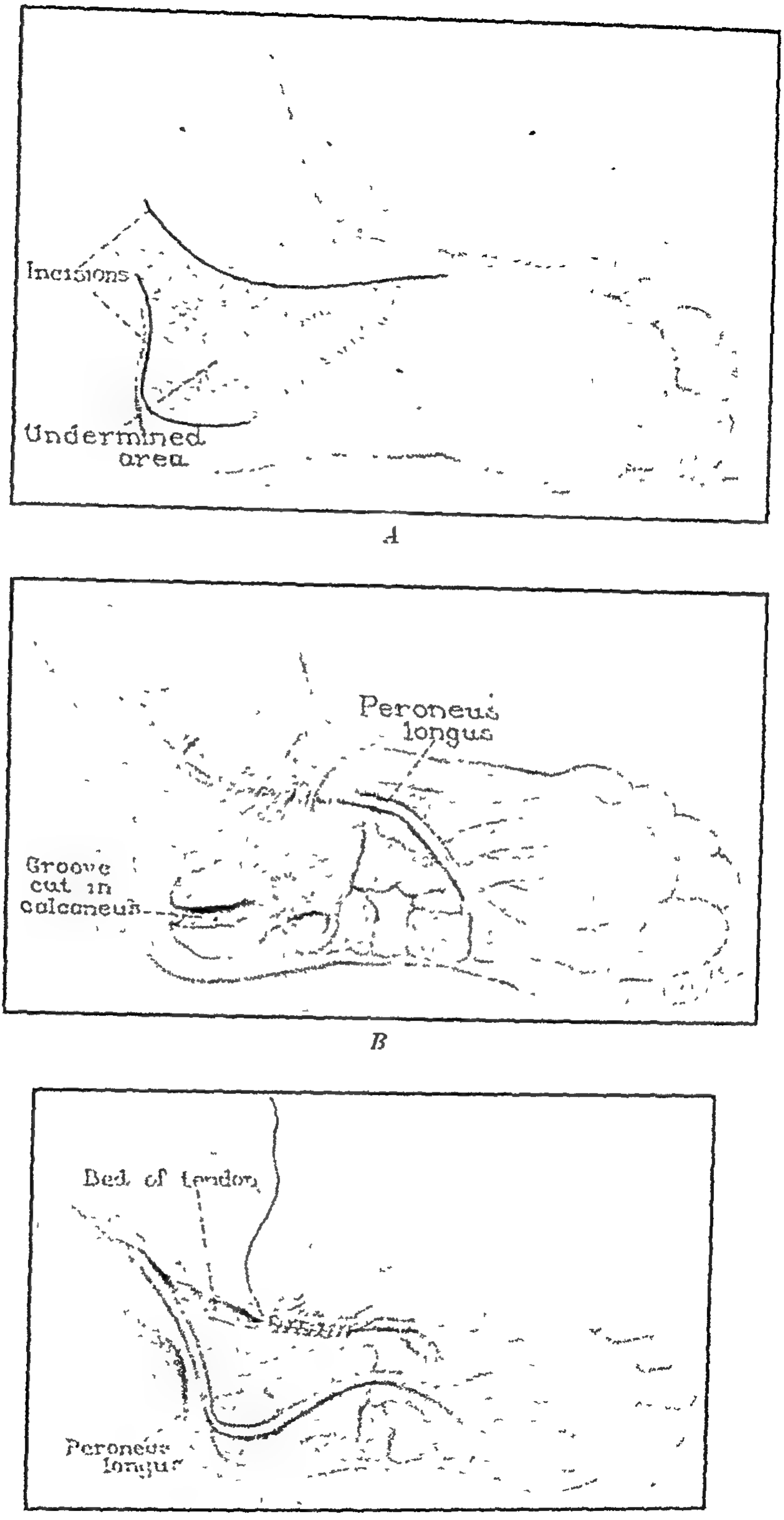


Fig. 312.—Translocation of peroneus longus tendon. *A*, Skin incision and stippling indicating area of tissue undermined. *B*, Groove in calcaneus for reception of peroneus longus tendon. *C*, Tendon mobilized from its bed and transferred to prepared groove. Closure of peroneal retinaculum. (Bickel and Moe, courtesy of Surg., Gynec. and Obst.)

(Note: Young curves the heel incision around to the medial side of the foot to keep the skin flap broader, insuring a better blood supply for the flap. He advises that the dissection be carried out subperiosteally along the os calcis.)

CALCANEUS DEFORMITY

The operations for the correction of calcaneus deformity are chiefly astragalectomy and subastragalar or other types of arthrodesis. Putti designed an anterior block which is analogous to Campbell's posterior block. Jones devised a two-stage operation. Campbell designed an *osteotomy of the os calcis.* *Subcutaneous or open plantar fasciotomy* may be performed in addition. Whitman recommended astragalectomy. After removing the astragalus through a lateral incision, he displaced the foot backward and made a new bed for the lower ends of the tibia and fibula anterior to their normal positions so that, on the inner border, the tibia articulated with the scaphoid and, on the outer

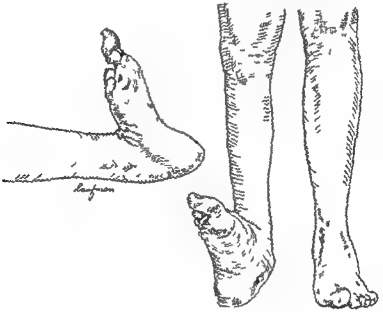


Fig. 313.—Extreme talipes calcaneovalgus due to poliomyelitis. (Redrawn from photographs.)

border, the fibula rested on the cuboid. Transplantation of the peroneals into the Achilles tendon may be done to strengthen the calf group. Astragalectomy should be performed only on older children and in selected cases.

Putti's operation consists in driving a wedge-shaped piece of bone transversely into the anterior part of the astragalus so that in the movement of the calcaneus there are both a superior and an anterior bone block.

The Whitman loop operation was designed for the correction of a paralytic equinovalgus in a foot in which all the muscles about the ankle except one or both of the tibials are active. The steps are as follows: (1) tenotomy of the Achilles tendon, (2) cutting of the

peroneus tertius at its insertion; (3) drawing of the peroneus brevis through the sheath of the tibialis anticus and its suture to the attachment of the latter tendon and the periosteum; (4) suture of the extensor hallucis longus and peroneus tertius to the scaphoid; and (5) fixation of the leg at a right angle and inverted.

Pes cavus is discussed in Chapter VIII.

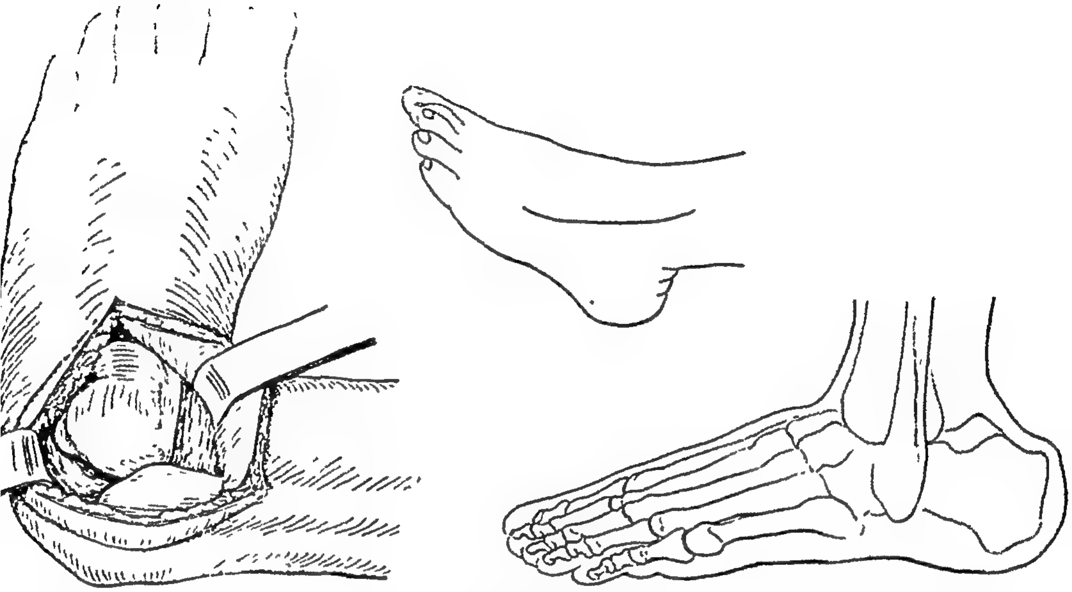


FIG. 314.—Whitman astragalectomy (Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

STABILIZATION OF THE FLAIL LEG

The flail leg is one in which the hip, knee, and ankle are flail. For the stabilization of a leg of this type, which presents a difficult problem, several methods are used. One is fusion of the hip, knee, and ankle. In another, only the hip and ankle are fused. When this is done the freely moving knee requires protection by a brace. A third method is the application of a brace with a lock joint at the knee joint with limited motion at the ankle and hip.

CHAPTER XXVI

SPASTIC PARALYSIS INVOLVING THE FOOT AND ANKLE

SPASTIC PARALYSIS OF INFANCY AND CHILDHOOD

SPASTIC paralysis is a condition manifested by hypertonicity of skeletal muscles. The term cerebral palsy includes all conditions affecting the normal control of the motor system (arms, legs, trunk, and speech) arising from intracranial lesions. A variety of these disturbances include spastic paralysis, athetosis, flaccid paralysis (of cerebral origin), tremor, rigidity and ataxia. They may be congenital or acquired. The most important types are infantile, cerebral, and spinal. The pathological changes may be in the central, spinal, sympathetic, or peripheral nervous systems. The victim of spastic paralysis has not lost power in any muscle group, but has lost the capacity to contract the muscles voluntarily and is unable to combine contractions of muscles into purposeful movements in a smooth and well-ordered manner. The condition is a dyskinesia rather than an asthenia or paralysis.

Cerebral spastic paralysis of infancy and childhood is characterized by impairment of voluntary muscle control with consequent incoordination of movements. Frequently the tendon reflexes are increased. After a period of time, deformities result. The condition is due to a lesion of the subcortical cerebral motor centers affecting the upper motor neurons.

Nomenclature.—Spastic paralysis of infancy is called "Little's disease," or "infantile cerebral spastic paralysis." If it involves only one extremity, the term "monoplegia" is used, if half of the body, "hemiplegia," if both lower extremities, "paraplegia," and if both arms and legs, "diplegia" or "quadriplegia."

Etiology.—The causes of congenital spastic paralysis are defective development of the intrinsic fiber tracts of the brain or pyramidal tracts, and intra-uterine brain softening resulting in hemorrhage and cysts. The causes of acquired spastic paralysis are hemorrhage occurring at birth, circulatory lesions, and disease of the central nervous system occurring in childhood. Trauma sustained at birth usually causes meningeal rather than cerebral hemorrhage. In many cases the paralysis is the result of over-vigorous treatment of asphyxia neonatorum. "The accoucheur spanks the baby until he himself is blue in the face and the baby is black and blue in other places." Most

of the acquired cases occur during the first few years of life. In childhood, the diseases causing spastic paralysis are meningitis, cerebral infections, specific encephalitis, and the encephalitic complications of scarlet fever, whooping cough, measles, and diphtheria. The circulatory changes are hemorrhage, embolism, and thrombosis Dickson classifies the causes of spastic paralysis as: (1) Intra-uterine, including congenital defects of the cerebral cortex or pyramidal tracts, syphilis, and intra-uterine injury. (2) Intracranial hemorrhage occurring during birth. This hemorrhage may come from the veins overlying the cerebral cortex, but is usually from the vein of Galen and is caused by trauma produced by forceps, protracted and difficult labor, and hemorrhagic disease of the newborn. (3) Conditions occurring after birth, such as meningeal hemorrhage, embolism, and thrombosis due to syphilis and other causes, including suppurative meningitis and hydrocephalus.

Pathology.—The lesion is in the upper motor neuron. The essential pathological change occurs in the motor area of the brain, with descending degeneration of the pyramidal and lateral columns of the spinal cord. The local circulatory changes are arteritis, endarteritis, periarteritis, and venous thrombosis. Encephalitis, chronic meningitis, and possibly sympathetic ramitis or ganglionitis may be present. As stated by Dickson, the lesion is that of cerebral hemorrhage with the formation of a clot and the destruction of cerebral tissue either on the surface of the brain or within it. Such destruction obliterates one or more cortical centers, thereby interfering with the tracts leading from the cortex to the spinal gray matter. The result is chronic muscle spasm, which holds whole limbs or portions of them in malposition. Eventually, anatomical or structural shortening is added to the physiological contracture, and the deformity becomes fixed.

In a study of a large series of cases of chronic paralysis due to cerebral hemorrhage at birth, Sharpe found that most of the patients were first-born males delivered at term by difficult labor, especially labor requiring medium-high forceps and version with breech extraction.

Symptoms.—The symptoms of spastic paralysis are due to involvement of the motor and the locomotor apparatus. Speech defects are common. The motor symptoms consist of rigidity or hypertonicity of the skeletal muscles rather than a paralysis. There is a "twist" in the innervation of these muscles. An excess of stimuli produces purposeless movements and lack of coördination. Sherrington's principle of reciprocal innervation is disturbed in that when a flexor muscle attempts to contract, the opposing extensor muscle does not relax as it should. During the first week, drowsiness, difficulty in nursing, and signs of cortical irritability are often noted. Spasticity of the legs is usually not observed during the seventh, eighth, or ninth months;

retardation in walking and talking completes the clinical picture A spastic child appears to be in a constant state of stage fright

The locomotor symptoms are disturbances of gait These are due to disorders of muscle function, contractures and deformities The spasticity may be monoplegic, hemiplegic paraplegic or diplegic The loss of muscle control causes difficulty in originating or carrying out purposeful movements In some cases the movement opposite to that desired occurs For example, the normal person, in stepping forward, abducts the thigh, the spastic individual adducts it Contractures are due to imbalance of the muscles, the stronger muscles overcoming the weaker

A spastic contracture is a tonic reflex contracture of the muscles due to a spinal reflex released from the normal inhibitory control of the higher centers of the central nervous system It disappears during sleep, under anesthesia, and when the reflex arc is interrupted in any part of its course According to Bankhart, spastic paralysis is not a disease but a physiological state, the natural physiological result of the anatomical lesion present It resembles to some extent decerebrate rigidity, which can be produced experimentally by sectioning the brain above the level of the mid-brain Such a lesion removes the inhibitory and controlling influence of the cerebral cortex from the parts of the central nervous system below, with the result that these parts enter into a state of abnormal reflex activity In most cases of cerebral paralysis there is some degree of mental deficiency

With reference to athetosis, Crothers speaks of "extrapyramidal chaos" and discusses what he calls the "physiological residue" He emphasizes the importance of the intellectual level in the presence of a fixed disability The mental appraisal of a child suffering from spastic paralysis is important

Deformities are due to changes in the muscles, tendons, fasciæ, ligaments, bones, joints, and joint capsules The most common deformities are the following In the foot, an equinus, more commonly with varus, at the knee, flexion with valgus, at the hip, flexion, adduction and inward rotation, in the upper extremity, flexion of the fingers with flexion and adduction of the thumb, at the wrist, palmar flexion, in the forearm, pronation, at the elbow, flexion and flexion-adduction, and at the shoulder, inward rotation In cases of marked adductor muscle spasm, a condition of cross-legs with "scissors gait" is produced The most common deformity is drop-foot or talipes equinus As the person walks he presents the "slapping" foot or the "klopping" foot He makes a noise as though he were wearing dutch wooden shoes

Neurological symptoms are ankle clonus, an increase in the tendon reflexes especially of the Achilles, patella, triceps, biceps, and pronator tendons The Babinski, Oppenheim, and Gordon reactions are usu-

ally elicited easily. Facial paralysis may occur. Trophic disturbances, ataxia, clonic contractures, tremors, and athetosis are common. The mentality of the patients varies from normalcy to imbecility. In certain cases there is a retardation of mental development due in part to the cerebral insult and in part to the restricted life of the child, with its lack of educational opportunities gained from association with other children. Some of the victims are placid and contented, while others are irritable, obstinate, and destructive.

According to Singer, the symptoms which are practically exclusively motor include: (1) inability to carry out intended acts smoothly and easily; (2) alterations in muscle tone—either an increase or a diminution, spasticity or flaccidity; and (3) irregular, involuntary athetotic or choreiform movements and irregular tremor. The lesion may involve the head, trunk, and extremities on both sides or may be limited to one side of the body or even to one limb or portion of the body. There is frequently a defect of speech (aphasia); many patients are completely mute or say only a few words slowly and more or less unintelligibly.

It must be remembered that because of the disorder of movement, the ordinary tests of intelligence which involve the use of speech or the performance of skilled acts are not applicable

The following outline is useful in recording the findings:

SPASTIC PARALYSIS CARD

Case No.

Name	Age	Address	'Phone No.
Referred by		Address	'Phone No.
Complaint?			
Duration?			
Cause?			
Obstetric history?			
Mentality?	Intelligence coefficient?		
Can patient walk?	Without aid?	With aid of	
Can patient talk?			
Previous treatment	Physical therapy	Neuromuscular training	
	Massage	Electricity	
	Psychotherapy	Operation	
Progress?			

EXAMINATION

General impression

What is the mental background? Intelligence? Emotions?

Patient walking: Aid necessary?

Type of walk? Atonic? Hypertonic?

Balance—ataxia?

Are there any mechanical obstructions, *i.e.*, contractures or deformities?

Can he walk backward? Sideways? Hop?

Lying supine Trophic disturbance

Can patient place extremities where directed? Do they remain there?

Can the examiner place extremities in various positions?

Do they remain there? (Lengthening and shortening reactions)

Is the patient's difficulty

In changing his position? In maintaining his position?

Are his reflex movements under control? Is reflex activity increased or depressed?

Can patient inhibit his movements?

Presence or absence of cortical control of group movements

Contractures? Do they prevent full range of movement and to what extent?

Upper extremity

Lower extremity

Knee jerk

Is it present?

Ease of elicitation? Ease of relaxation?

Amplitude of movement?

Time ratio of leg extension and fall?

Stepladder rise?

When quadriceps is stimulated do hamstrings relax or contract?

Does patient possess reciprocal innervation?

Relative amount of plastic tone?

Relative amount of contractile tone?

Are there superimposed corticospinal movements? Tremor?

Athetosis? Influence of voluntary motion { Affected side / Non-affected side

Condition of spinal reflexes?

Babinski Oppenheim Gordon

Ankle clonus Patellar tendon clonus

Does the patient exhibit phenomena more like those of the decerebrate animal or those of the spinal animal?

Arm reflexes?

Excess of associated movements

Sitting position

Knee jerks

Arm examination

Habitually assumed position of

	Relaxed	Excited
Fingers		
Wrist		
Forearm		
Arm		
Foot		

Wrist jerk Triceps jerk

Pronator jerk Radial jerk

Is plastic tone increased?

Is contractile tone increased?

Recommendations:
- Neuromuscular education — Psychotherapy
- Passive motion — Massage
- Muscle and tendon operations { Upper extremity / Lower extremity }
- Alcohol injection of nerves — Stoffel operation
- Förster operation
- Royle sympathetic ramisection
- Bone operation, osteotomy, etc.

Treatment carried out by:
- Results of treatment:
  - Early
  - Late

Diagnosis.—A differentiation must be made from anterior poliomyelitis, cerebral and cerebellar tumors, myotonia congenita (Thomsen's disease), dystonia musculorum deformans, progressive lenticular degeneration (Wilson's disease), pseudohypertrophic muscular paralysis, idiocy, hydrocephalus, and spinal spastic paralysis. Each of these conditions has its cardinal signs and symptoms.

Prognosis.—Ryerson considers cerebral spastic paralysis in children one of the unsolved problems of orthopædic and neurological surgery. The prognosis as to improvement depends chiefly upon the extent of cerebral damage and the treatment given. Unfavorable factors are poor mentality, contractures, athetosis, and a progressively increasing course. Contractures and deformities are like hurdles in the child's path; the hurdles must be removed and the path made smoother. Operations remove some of the obstructions to neuromuscular education or reëducation, and removal of physical defects hastens the recovery of mental faculties. Idiocy makes the patient unsuitable for operative treatment, but mental impairment of less degree is not a contraindication. Operations which result in physical improvement are usually followed by considerable mental improvement. Renewed interest in life and improvement of the general health follow the correction of physical defects.

Dunn emphasized the importance of the following three factors in spastic paralysis: (1) the mentality of the child, (2) the degree of spasticity of the muscles, and (3) the voluntary control which may be present. He stated that the prognosis depends upon the degree of voluntary control of the limb rather than upon the particular operation performed to overcome the spasm of the muscles responsible for the deformity. It is possible to set almost any spastic child upon his feet and to get him walking somehow, provided he has sufficient intelligence to try to use his legs.

Treatment.—The treatment includes prophylactic and remedial measures.

Measures Employed Are
1 Shoe modifications 2 Reëducation 3 Aids in walking 4 Braces 5 Psychology, and in some cases, 6 Surgery offers a great deal

Phelps emphasizes the fact that careful and accurate diagnosis is imperative He is very conservative regarding surgery He calls attention to the importance of non-surgical measures before and after operative procedures

Prophylaxis —The most important prophylactic measures are careful obstetrics and early treatment of newborn babies who show symptoms of cerebral irritation or increased intracranial pressure Kugelmass recommends daily spinal or cisternal puncture, he prefers the latter According to Sharpe and Maclaire, every infant in whom these signs are noted should be subjected to lumbar puncture If hemorrhagic fluid is obtained, repeated punctures should be made, and provided the bleeding persists and the cerebrospinal fluid pressure cannot be reduced, a modified subtemporal decompression of the skull with cranial drainage should be performed For cases with bloody cerebrospinal fluid under varying degrees of increased pressure, repeated lumbar puncture or spinal drainage every six to twenty-four hours is advocated

Ryerson believes that spasticity of the arms, legs, or neck is significant of intracranial disturbance In cases of doubt, a lumbar puncture should be made When blood is found in the cerebrospinal fluid, repeated punctures may relieve all of the symptoms If the spasticity persists, a cranial decompression and exploration should be done

Non-operative treatment consists of measures to improve the general condition In order to prevent undue stimulation of an already hypersensitive nervous mechanism, the patient must live a quiet life In the case of a child of five years, I have had some success with luminal in doses of gr ½ three times daily

In the treatment of spastic paralysis there has been proposed the use of such drugs as curare (intocostrin which is the purified curare), and erythroidin Some observers have reported remarkable results in the use of these drugs, but they are not in general use because (1) some of the untoward effects have not been eliminated, (2) the dosage is still undetermined, (3) some are not available to the profession

Curare has been discussed as a drug to be used in spastic paralytic cases The chief writers on this subject are Burman and Pusitz The

indications, dosage and intervals of dosage are still under discussion. The complications are not considered to be minor ones but are not well known.

Myanesin has been reported to have the physiological effect of curare without its harmful effect.

Neuromuscular or Psychomotor Education or Reëducation.—By carefully graduated, persistent, personal training, the child should be taught simple group movements. The object is to obtain relaxation, coördination, and concentration; to inhibit antagonistic movements; to improve the movements present; to develop new ones; to reduce awkwardness of movements; and to obtain balance. The parents, nurses, and teachers should be strict during exercise periods. Carlson

Fig. 315.—Drop-foot apparatus. Wire uprights and cuff, adjustable wire pivots in heel, ⅛ inch wire passes through the heel. Elastic webbing sewed to shoe as a check-rein. (Mayo General Hospital Brace Shop, Sgt. Burger.)

finds the harmonica helpful in reducing the tension of spastic children. In the case of a young boy who walked with one foot in equinus he noted that the equinus completely disappeared when the boy put one hand in a pocket. He advised getting a spastic child out of its home. The parents sometimes offer a definite problem.

The educational part of the program for spastic paralytics which is carried out at the Spaulding School for Crippled Children in Chicago consists of three main divisions: (1) physical training, (2) academic training, and (3) social training.

A satisfactory "walker" consists of a four-post cage on wheels with adjustable axillary crutches. Crothers says: "Some physical therapists are so enthusiastic that they are unsafe." Heat is of

value to relax muscles Extreme gentleness in handling the patient is important The acme of performance is a movement directed by the brain and carried out by the proper muscle or group of muscles without an overflow of nerve impulses producing purposeless movements In some of Singer's cases the improvement has been sudden and startling It seemed almost as though some obstruction had been suddenly removed and "the flow of function" had started immediately

Swimming —Under careful instruction, underwater gymnastics may be very valuable Lowman recommends that the water be at a temperature of 100° F or a little higher

Massage —Manipulation reduces the amount of fibrosis in a muscle, ligament, or capsule, but may be harmful

Electricity —Electric stimulation may cause harm because it adds more stimuli to nerves and muscles already overstimulated

When deformities result in spite of efforts to prevent them, they must be corrected Forcible manipulation of joints followed by the use of retention apparatus may be helpful if it is done gradually After the application of a cast or brace, one must be on guard for the development of stuttering It is due to the confused outlet for excess energy

Operative Treatment —Operations may be performed on tendons, muscles, fasciæ, joint capsules, and nerves

Tenotomy of the Achilles tendons, tibials, hamstrings, and adductors may be followed by marked improvement Tendon lengthening weakens the muscle very favorably In the case of the Achilles tendon there is danger of overlengthening followed by a calcaneus deformity which is much more disabling than the original equinus For this reason an open operation is desirable Myotomy is not practised extensively Muscle and tendon transplantations help to balance a joint Joint capsules and fasciæ are important resistive factors in the correction of deformity The former are amenable to capsulorrhaphy, the latter to fasciotomy

Spastic Flat-foot —Lapidus outlines 9 points regarding spastic flat-foot

1 A review of the literature on the so-called spastic flat-foot shows variable, often contradictory, theories concerning its etiology and treatment

2 The prevailing conception is that it is a reflectory spasticity of the pronators which develops in a flaccid flat-foot as a result of irritation of the tarsal joints, attributed to faulty statics and mechanics

3 No satisfactory explanation for the fact that the spasticity is always limited exclusively to the pronators can be found in the literature, although various theories have been advanced

4 The accepted standard treatment of the so-called spastic flat-foot

has been rest, immobilization physical therapy, manipulations, resection of peroneal tendons, or even induction of palsy of the pronators by interruption of conductivity of the peroneal nerve by means of injections or crushing of the nerve.

5. A review of the anatomy and mechanics of the subtalar joint shows that the interosseous talocalcaneal ligament is relaxed in pronation, and becomes tense in supination of the foot.

6. Lapidus offers the theory of the cause of the so-called spastic flat-foot as a lesion of the interosseous talocalcaneal ligament or of the subtalar joint with reflex spasm of the pronators to produce relaxation of the above ligament.

7. The syndrome of spasticity of the pronators is not peculiar to flat-foot but is often observed in normal feet or even in cases of cavus Therefore, the terms "spastic subtalar lesion" or "subtalar arthritis with spasm of the pronators" are offered as more appropriate designations than "spastic flat-foot."

8. Lapidus presents a classification of cases with the method of treatment employed.

9. The lesion of the interosseous talocalcaneal ligament is the primary cause and spasm of the pronators is the consequence. Therefore, any operation designed to eliminate the action of the pronator muscles (tenotomy or interruption of peroneal nerve) is strongly condemned as being unsound, futile, and often harmful.

The Durham Operation to Correct Internal Rotation of the Thigh in Cases of Spastic Paralysis.—Internal rotation of the thigh is a common, disabling, and persistent deformity in patients with spastic paralysis. It is found mainly in conjunction with the more obvious flexor and adductor spasm and for that reason its importance as a separate factor has been overlooked.

For the release of the internal rotating muscles a short diagonal incision is made from behind forward over the greater trochanter. The tensor fasciæ latæ is divided and retracted. The gluteus medius and the gluteus minimus are exposed at their insertions into the greater trochanter. By rotating the thigh externally, one can readily identify these muscles. A dissector is passed under that portion of the tendons which is inserted anteriorly and below the tip of the trochanter. The tendons are then divided close to their insertions, any remaining tight fascial bands are likewise divided. The thigh can then be placed in complete unresisted external rotation. If the fascia late is tense and separates widely when the thigh is rotated outward, it is left unsutured and allowed to retract; otherwise it may be reapproximated. The subcutaneous fat and the skin are closed by separate layers of sutures

Plaster immobilization is used to maintain the thigh in abduction

and full external rotation When the operation is unilateral, a single hip spica is sufficient *When the operation is bilateral* it is necessary to put on two long leg casts with a connecting bar to maintain the external rotation The casts are removed at the end of six or eight weeks at which time physical therapy and walking exercises are begun

Operation on bones is of value in cases of knock-knee An osteotomy may be done by drilling several holes, connecting them by means of a small osteotome, and twisting to correct the deformity (Royle) *In some cases arthrodeses of the bones of the foot are* indicated The value of peripheral nerve resection has been definitely proved The transfer of muscle pull has been found helpful, and the usefulness of sympathectomy in selected cases is no longer in doubt

EQUINUS

Beware of changing an equinus foot into a calcaneus one The Lambrinudi operation is described in Chapter XXV

DEFORMITIES OF LEG, THIGH AND HIP

Flexion deformity at the knee should be corrected because of the tendency toward subluxation In order to prevent this it is sometimes necessary to divide the posterior ligament of the knee joint, in which case care must be taken in drawing the important popliteal structures aside However the hamstring tendons must be fully exposed in order to avoid dividing the common peroneal nerve which runs along with the biceps tendon for 3 or 4 inches

Adduction at the hip can usually be corrected by stretching, but in cases with greater rigidity less damage is done to the soft tissues if *the tendon of the adductor longus* is divided close to its superficial origin at the body of the os pubis Flexion of the hip can be corrected by dividing the sartorius, both heads of origin of the rectus femoris, and the tensor fasciae femoris

Transplantation of the biceps tendon at the knee is advisable in *selected cases* Such an operation helps balance, but does not reduce the sum total of spasticity or lack of control

In doing the biceps transplantation, it is necessary to free the muscle high so as to obtain a more direct pull on the patella The common peroneal nerve which lies close alongside the biceps must not be injured The tendon should be implanted in the bone In spite of a good operative technic, the patella frequently becomes dislocated by the indirect pull, with resulting serious disability

Operation on Nerves —Alcoholization Injection of a peripheral nerve with 60 per cent alcohol renders the nerve functionless for three or four months during which time correction of deformities may be

attempted and some of the spasticity relieved. Fitch introduces 80 per cent alcohol into or near the nerve: this procedure is not without danger.

Förster Operation.—Förster proposed intraspinal section of the posterior nerve roots, dorsal to their ganglions. In this operation, known as "rhizotomy," the dura is exposed by preliminary laminectomy, the posterior nerve roots are identified, and the third, fourth, and fifth lumbar roots and the first and sometimes the second sacral roots are divided. Recently Förster advocated sparing the four lower cervical roots and the first thoracic root. This is a severe and highly technical operation.

Stoffel Operation.—Stoffel's theory is that in all cases with a quantitative increase in the number of impulses going down a nerve to muscles, the condition may be corrected by resecting a part of the peripheral nerve. This operation is performed on the sciatic, internal and external popliteals, and obturator nerves; its object is to diminish the innervation of the spastic muscles. This is a quantitative measure based on the fact that every peripheral nerve has a certain definite internal topography or pattern. It may be combined with other procedures such as tenotomy or osteotomy.

In presenting the technic, I selected Steindler's description. By careful anatomical studies, Stoffel developed a topographical chart of the cross-section anatomy of the peripheral nerves of the lumbo-sacral plexus. To determine the nerve supply to various muscles one can depend largely on electrical stimulation applied during the operation.

In the tibial nerve Stoffel recognizes a dorsal bundle for the gastrocnemius, a dorsolateral bundle for the ventral portion of the soleus, a ventrolateral bundle for the tibialis posticus, and a ventromedial bundle for the flexors of the toes. In the peroneal nerve he recognizes a median superficial and a lateral deeper bundle, the former for the peronei and the latter for the tibialis anticus.

Adductor Spasticity.—Resection of the obturator nerve: Steindler resects the obturator nerve after its exit from the obturator foramen. It is often necessary to carry out tenotomies of the adductors also because of the structural shortening of the latter muscles. A longitudinal incision having been made along the course of the adductor longus, this muscle is severed and drawn aside to expose the adductor brevis. Running over the anterior surface of this muscle one sees the anterior or superficial branch of the obturator nerve which supplies the gracilis, adductor longus, and all or a portion of the adductor brevis muscles. This nerve is picked up and resected. Behind the adductor brevis can be seen the posterior branch which supplies the obturator externus, part of the adductor magnus and part of the adductor brevis muscles. The adductor magnus also receives a nerve supply from the

sciatic nerve, and the hamstring muscles have a partial adductor component

In severe cases in which the entire obturator is to be divided, some surgeons prefer the abdominal extraperitoneal route of Seelig, using the Pfannenstiel incision The wound is less likely to become contaminated than a wound on the thigh, and the whole nerve can be removed with greater certainty The presence of an accessory obturator is the only possible source of error The nerve is isolated on the lateral wall of the pelvis as it approaches the obturator foramen After the operation the thighs should be held in moderate abduction just sufficient for nursing care, while the wound is healing The two sides can be reached through a single incision, the peritoneum being stripped from the parietes in a downward and outward direction until the pelvic brim has been reached and passed

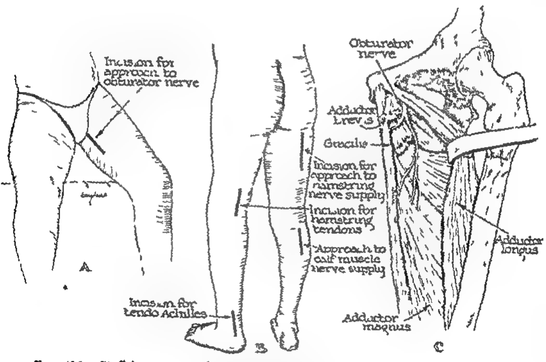


FIG 316 —Stoffel operation—lower extremity (Redrawn from Von Lackum Jour Bone and Joint Surg)

Hamstring and Achilles Tendon Contractures —Resection of the sciatic nerve The nerve is exposed by an incision beginning at the gluteal fold mid-way between the tuberosity of the ischium and the greater trochanter The bundles supplying the long head of the biceps, semimembranosus, and semitendinosus are situated at the median aspect of the nerve The branches are followed close to their insertion into the muscles In moderate cases the nerve supplies to the biceps and semitendinosus are resected and in severe cases the branches to the semitendinosus in addition

Spastic Equinus and Equinovarus.—The internal popliteal nerve is exposed in the popliteal space. The first branch comes off from the internal and posterior aspect. This is the cutaneus suræ. The next two branches supply the inner and outer heads of the gastrocnemius Running behind is the nerve for the dorsal portion of the soleus and plantaris. The branches are followed up to their points of entry into the muscles. In moderate cases, the nerves to the two heads of the gastrocnemius are resected. In more severe cases one-half the supply to the dorsal portion of the soleus is excised in addition. In

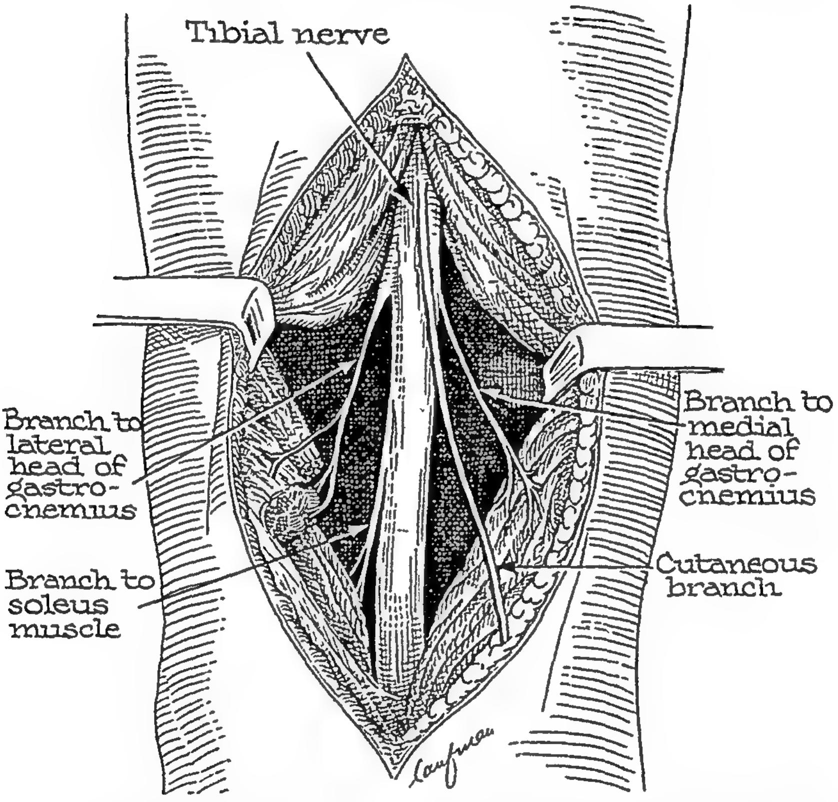


Fig. 317.—Exposure of tibial nerve and its inner and outer branches to heads of gastrocnemius and soleus muscles. The first and most superficial is a cutaneous branch The branch to the tibialis posticus muscle comes off at a lower level, as the nerve disappears beneath the soleus muscle (Redrawn from Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

the severest cases the entire supply to the dorsal portion of the soleus is resected. In addition to this, a portion of the supply to the flexor digitorum longus and, in cases with a tendency toward varus, a portion of the supply to the tibialis posticus is resected. In a series of cases of spasmodic flat-foot, Dunn crushed the motor nerve branches to the peroneal muscles.

Fairbank believes that while Stoffel's operation is best for adductor spasm, the open lengthening of the Achilles tendon is best for equinus For knee flexion in younger children he prefers Stoffel's method; for

knee flexion in older children, the Stoffel operation with tenotomy For internal rotation of the leg he prefers to cut the superior gluteal nerve and its branches above the trochanter

Sympathetic Nerves —Renewed interest in the treatment of spastic paralysis was stimulated by the work of Royle, an orthopædic surgeon, and Hunter, an anatomist and neurologist, on sympathetic ramisectomy Surgery on the sympathetic nervous system includes operations on the chain, ganglia, and white and gray rami communicantes in the

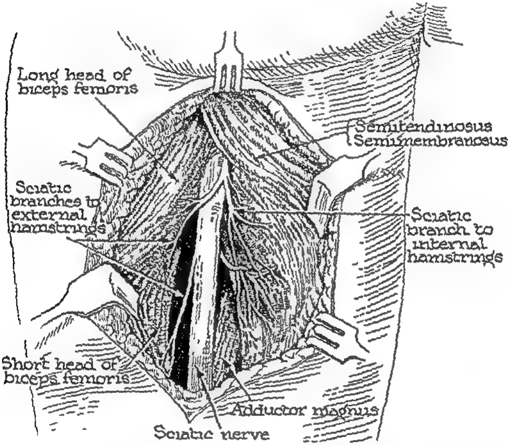


Fig 318 —Exposure of branches of sciatic nerve to hamstring muscles By retraction of long head of biceps to outer side a better exposure is obtained All branches come from a common trunk on the medial side of the nerve except that to the short head of the biceps which is distal and on the lateral side (Redrawn from Campbell Operative Orthopedics courtesy of The C V Mosby Company)

cervical and lumbar regions In two articles which appeared in the *Medical Journal of Australia* in 1924, Royle and Hunter revived the theory of the dual innervation of skeletal muscle and advocated the operations of cervical and lumbar sympathetic ramisection With the belief that the increased "plastic tone" manifested by spastic muscles is due to impulses transmitted through the gray sympathetic rami, Royle advised cutting or avulsing these structures

Royle Operation—Sympathetic Ramisection —Royle suggested the operation of ramisection to relieve spastic paralysis His most recent

technic is trunk section. In the lumbar region the rami opposite the second, third, and fourth sympathetic segments are cut or avulsed and the sympathetic cord is severed below the fourth lumbar ganglion.

Adson proposed and performed ganglionectomy and trunk resection to ensure complete interruption of vasoconstrictor fibers. The operation should be complemented by neuromuscular education and re-education. When contractures are present, operations are necessary on muscles, tendons, or bones. Kanavel, Pollock, and Davis have been unable to confirm Royle and Hunter's work, either experimentally or clinically. Forbes, Cannon, O'Connor, Hopkins, and Miller believe that if any improvement follows this operation it is incidental and not due to the interruption of nerve impulses arising in the sympathetic nervous system.

In the opinion of Steindler and Lindemann, there is evidence that in some cases the operation is followed by improvement in function. Gray ramisectomy of the sympathetic system has a place in the treatment of cases manifesting plastic tone or lengthening and shortening reactions. It requires a thorough knowledge of the regional anatomy.

Putnam proposed the operation of partial cordotomy, sectioning of the extrapyramidal motor tract, and Oldberg and Chandler reported 6 cases in which it was performed.

UNUSUAL TYPES OF SPASTIC PARALYSIS

Hydrocephalus.—The type of spastic paralysis associated with hydrocephalus is very resistant to treatment. I saw one patient who had been operated upon at the age of six weeks. A glass tube was inserted in a hole drilled through the body of the fifth lumbar vertebra so that the spinal fluid drained into the peritoneal cavity. When she was nine years of age I performed an obturator neurectomy, adductor myotomy and subastragalar arthrodesis.

Spina Bifida and Meningocele.—Sharpe recommends a repair operation performed within the first three months of life and followed by determinations of the intracranial pressure at least once a month by means of ophthalmoscopic examinations and lumbar puncture tests until the danger of the development of hydrocephalus has passed.

Encephalitis.—Contractures and deformities due to encephalitis should be guarded against and treated as indicated in the discussions on poliomyelitis and spastic paralysis.

Spastic Paralysis in Adults.—Spastic paralysis in adults is caused chiefly by apoplexy due to circulatory disturbances in the brain, *viz.*, hemorrhage, edema, rupture, or the plugging up of a blood-vessel by a thrombus or embolus. A one-sided paralysis involving the arm and leg (hemiplegia) usually follows and may be accompanied by a disturbance of speech if the lesion is in the left side of the brain.

CHAPTER XXVII

PERIPHERAL VASCULAR LESIONS OF THE LOWER EXTREMITIES

AFFECTIONS OF ARTERIES

CIRCULATORY lesions of the foot and ankle fall into three groups—those involving the arteries, those affecting the veins and those involving the lymphatics

The most important arterial conditions are arteriosclerosis thrombo-angiitis obliterans, Raynaud's disease, erythromelalgia, acrodynia, acroparesthesia, causalgia, trench foot, and chilblains

Affections of the veins include varicose veins, phlebitis, thrombophlebitis, phlebothrombosis and varicose ulcers

Lymphatic disturbances are important from the standpoint of infection and the spread of infection into the system

The causes of vascular lesions include hereditary, congenital, infectious, thermal, traumatic, toxic, metabolic, glandular, neurogenic, psychogenic, and neoplastic factors It has been estimated that 85 per cent of the cases of sclerosis of the peripheral arteries and 98 per cent of the cases of thrombo-angiitis obliterans occur in men, whereas 90 per cent of the cases of Raynaud's disease are found in women Men are particularly subject to organic lesions and women to functional derangements of the peripheral vascular system

In the urines of 43 of 50 patients with arterial disease, *Horton* and Osterberg found amounts of lead equal to the quantity found in lead poisoning None of the patients had symptoms of plumbism Improvement was coincident with disappearance of the urinary lead

Classification —Peripheral vascular occlusions may be mechanical or dynamic Mechanical or organic occlusions obstruct the lumen with a clot or constrict it by narrowing the vessel wall or compressing the vessel externally Dynamic occlusions may be due to vessel spasm or vessel paralysis De Takáts uses the following classification

1 Mechanical occlusions	A Acute	Traumatic Embolic
	B Chronic	Degenerative arteriosclerosis Inflammatory thrombo-angiitis obliterans
2 Dynamic occlusions	A Spastic	Raynaud Cervical rib or spina bifida
	B Paralytic	Endocrine disorders Erythromelalgia

Peripheral Vascular Lesions.—Allen, Barker and Hines* state, the physician who is interested in diseases of the peripheral circulation will inform himself relative to the symptoms of each individual disease and practice physical examination until he becomes adept enough to recognize the normal and the abnormal. If his curiosity leads him further, he may inform himself relative to the numerous contributions that are made about pathologic and physiologic disturbances, which are associated with disturbances of the peripheral circulation, as well as relative to the numerous highly specialized methods of examination which can be utilized in advancing the knowledge of the diseases of the peripheral circulation and in adding to the accuracy of the diagnosis. From a diagnostic standpoint, however, a firm foundation of knowledge of symptoms of disturbances of the peripheral circulation and the ability to carry out examination accurately will suffice.

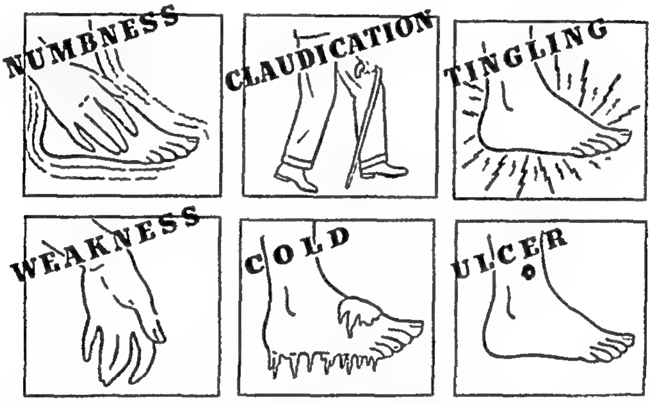


FIG. 319—Symptoms of peripheral vascular lesions. (Courtesy of the Burdick Corporation.)

The first step in the recognition of disturbances of the peripheral circulation is to elicit a careful, complete history of the patient's complaints.

If the patient complains of (1) pain which is induced by exercise and relieved by rest, influenced by posture, localized to one digit or one side, or is paroxysmal; (2) changes in color, especially those which are paroxysmal or influenced by elevation and dependency; (3) ulceration, gangrene, scleroderma, impaired nail growth, excessive calluses, or paronychial infections; (4) enlargement or smallness of extremities; (5) excessively cold or warm extremities; or (6) abnormal pulsations or enlarged veins, disease of the peripheral circulation should be suspected.

If the complaints clearly have not originated in disturbances of the peripheral circulation, physical examination can be carried out quickly to confirm the impression that the symptoms do not arise from dis-

* Allen, Barker and Hines, Peripheral Vascular Diseases, W. B. Saunders Co., 1946.

turbances of the peripheral circulation. If, on the other hand, the complaints are definitely those of impaired circulation or possibly or probably those of impaired circulation, more detailed examination must be carried out.

The examination of the extremities of patients with suspected peripheral vascular disease is usually simple and can be carried out quickly.

The examiner must answer the following questions in order to complete the examination:

1. Is swelling, atrophy, elongation, or shortening of the limbs present?
2. Is ulceration, gangrene, scleroderma, eczema, varices, or thrombophlebitis present?
3. Is the temperature of the skin abnormal?
4. Is the color of the skin abnormal? Do elevation and dependency of the extremities cause unusual discoloration of the skin?
5. Are pulsations in the peripheral arteries impaired?
6. Is there auscultatory evidence of arteriovenous fistula or aneurysm?

If the answer to all these questions is "No," all peripheral vascular diseases except Raynaud's disease and erythromelagia may be excluded. If the answer to any of these questions is "Yes," more detailed examination and analysis may be advisable.

The three chief steps in adequate examination of patients who are suspected of having peripheral vascular disease are inspection, palpation and auscultation.

Brown's classification of arterial vascular diseases is as follows:

Functional or vasomotor types	Local distribution	Vasoconstricting type	Raynaud's disease
		Vasodilating type	Erythromelalgia
	General distribution	Vasoconstricting type	Primary or essential hypertension, early stages
		Vasodilating type	Primary or essential hypotension
Organic types	Local distribution	1. Arteriosclerotic disease, senile gangrene, diabetic gangrene 2. Thrombo-angiitis obliterans 3. Simple thrombosis, embolism 4. Arteriovenous communications (congenital, acquired) 5. Aneurysm with or without thrombosis	
	General distribution	Arteriosclerosis 1. Primary 2. Secondary types due to hypertension, lead and so forth	

It is important from the standpoint of treatment to determine whether an arterial occlusion is organic or spastic in origin, and whether an organic occlusion is aggravated by a superimposed spasm. Many diagnostic procedures have been advocated to differentiate between organic and spastic vascular occlusions.

The important signs of peripheral arterial obstruction are plantar or digital ischemia, coldness and pain in the extremities, and a decrease of arterial pulsation.

Ischemia may produce pain varying in intensity from that of mild neuritis to the excruciating pain characteristic of sudden vascular occlusion. The pain of thrombo-angiitis obliterans is due to complete or partial occlusion of the small vessels of the nerves. It is said to be the result of ischemia of these nerves.

Occlusion of the arteries produces arterial insufficiency, claudication, ulcers, and gangrene. Inflammatory lesions in the walls of the arteries and veins may cause local symptoms.

Calcification of arteries of the legs appears in 65 per cent of males and 28 per cent of females more than fifty years of age. Occlusive disease of arteries of the legs is much more infrequent in females than in males.

Arterial occlusion may develop suddenly, as in peripheral arterial embolism, or gradually, as in arteriosclerosis or thrombo-angiitis obliterans. In embolic occlusion, a thrombus breaks loose from endocardial vegetations or from arteriosclerotic plaques and obstructs a large artery. The obstruction is sudden and complete. Gradual obstruction permits the development of compensatory collateral circulation.

The various clinical pictures observed in peripheral vascular diseases are due to functional or organic changes in the vascular tree. In the functional group, De Takáts includes: (1) the vasoconstricting type, accompanied by either the multiple phase color reaction (Raynaud's disease) or the one phase color reaction (acrocyanosis, dead finger, local syncope); and (2) the vasodilating type (primary erythromelalgia). In the former, the skin temperature of the extremity decreases, with a corresponding decrease in heat elimination, while in the latter it increases above the normal, with an increase in heat elimination. The two main subdivisions of the organic group are thrombo-angiitis obliterans and arteriosclerotic disease. The multiple phase color reaction is always present in Raynaud's disease and in approximately 25 per cent of cases of occlusive vascular disease. Such changes are very common in cases of thrombo-angiitis obliterans. In uncompensated cases of the organic group, blanching occurs when the extremity is elevated and rubor appears when it is in the dependent position. The red cold foot is due to circulatory insufficiency, and the red warm foot usually to some local infection. Gangrene may follow any surgical operation on a red cold foot, even the trimming of an ingrown toenail.

Tests of Circulatory Efficiency.—In testing for circulatory efficiency, the presence of swelling, edema, or phlebitis should be noted. In the following summary the simpler tests are given first:

1 The color of the skin when the limb is elevated, depressed, and level

2 The skin temperature as determined by the examiner's hand The dermatherm (thermocouple) is more precise

3 The presence or absence of pulsation in the dorsalis pedis and posterior tibial arteries

4 The rapidity of return of color following the release of pressure on the skin

5 The Moszkowicz test The change in the color of the skin which results from the alternate application and removal of a tourniquet is noted

6 The capillary pulse and pressure

7 Samuels' plantar ischemia test The patient reclining on a low bed is instructed to elevate both legs to an angle of 90 degrees and, while maintaining this position, to carry out fairly rapid movements of flexion and extension of both feet, using the ankle joints as pivots

8 The Landis test The forearm of the patient is immersed in water at a temperature of from 43 to 45° C for thirty-five minutes to produce vasodilatation in the lower extremities If the surface temperature of the toes rises above 31 5° C (89 8° F), obliterative structural disease of the arteries of the lower extremities can be ruled out If the surface temperature fails to rise to this level, organic arterial obstruction is probably present

9 The blood-pressure test Hines and Brown found that all persons react to the local application of cold stimuli with a rise in blood-pressure The subject is placed at rest for twenty minutes and the blood-pressure taken every five minutes until a constant level is obtained One hand is then immersed above the wrist for from twenty to thirty seconds in water at a temperature of from 4° to 5° C The systolic and diastolic blood-pressures immediately rise and then return to the basal level in from one to two minutes Similar results are obtained by placing a foot in cold water

10 The Pachon oscillometer test The degrees of occlusion in the main artery are indicated by a loss or diminution of oscillations below a certain level

11 The Stewart calorimeter test

12 The viscometer test Stern and Cohen found that the relative blood viscosity helps to differentiate the types of vascular occlusion

13 The time and color reaction following the intradermal and dermal injection of a 1 to 1,000 solution of histamine acid phosphate

14 The vasomotor index as determined by the typhoid vaccine-fever test Fever is induced with intravenous typhoid vaccine and the increase in the surface temperature of the limb measured at half-hour

intervals with a thermocouple-galvanometer. The vasomotor index equals the surface temperature minus the mouth temperature.

15. Vasomotor release by local anesthesia: Scott produces local anesthesia of the posterior tibial nerve. In Buerger's disease there is no change after this test. In vasospasm, there is a significant change.

16. The intracutaneous salt solution wheal test: This test, devised by McClure and Aldrich and used by Stern and others as a simple method of determining the efficiency of the arterial circulation in the extremities, is performed as follows: With a tuberculin syringe and a very fine needle, 0.2 cc. of an 0.85 per cent salt solution is injected intracutaneously. An injection is made first at the base of the great toe and then at 4-inch intervals up the leg and thigh. When the circulation is normal, sixty minutes or more are required for complete disappearance of the wheal produced by the injected fluid. In all cases of circulatory deficiency, the disappearance time is diminished. In the area just above the seat of gangrene it is frequently as low as five minutes. Readings below ten minutes have been found only in tissues immediately above areas of gangrene. Readings between ten and twenty-five minutes are suggestive of developing gangrene.

17. The histamine test: Starr, Lewis, Alexander, Caldwell, and Mayo use histamine endermically to differentiate states and degrees of occlusive vascular disease in the extremities. A small area of skin on the ankles or knees is cleansed with alcohol and allowed to dry. A drop of a 1 to 1,000 solution of histamine phosphate is then placed upon it and introduced into the epidermis by multiple needle punctures. The excess histamine is gently removed by sponging with gauze.

The characteristic response to the cutaneous application of histamine is described by Caldwell and Mayo as: (1) a reddish-purple spot, due to local capillary dilatation; (2) a local wheal, due to the transudation of serum from increased permeability of the capillaries, and (3) a flare, due to dilatation of the arteries by a local axonic reflex. In general, the wheals and flares are fully developed at the end of two and a half minutes. Any delay beyond this time is considered evidence of decreased circulation. In occlusive vascular lesions the reaction is delayed and reduced. In studies made on 65 normal persons, Weiss, Robb, and Blumgart injected 0.001 mg. of histamine phosphate in a dilution of 1 to 5,000 into an arm vein and noted the time that elapsed before the occurrence of flushing of the face. The time interval was found to range from seventeen to twenty-five seconds. In thromboangiitis obliterans it is lengthened to sixty-eight seconds, and in arteriosclerosis to a less extent. This test is useful in checking improvement in the collateral circulation following therapeutic measures and in determining the level of amputation. A positive histamine reaction indicates that the skin at the level of the injection has a fair

blood supply Amputation should never be done at a level at which the histamine reaction is negative

18 Opacity of the digits to transillumination Taylor and Parker found that in occlusive arterial disease of the extremities, the digits are more opaque to transillumination than under normal conditions They used a pocket flash light The patient was placed in a semi-darkened room, and the extremity elevated approximately 60 degrees from the horizontal

19 Sympathetic nerve block White advocates blocking the sympathetic nerves to determine the presence or absence of vasoconstriction

20 Peripheral nerve block The vasomotor fibers to the vessels run in the peripheral nerves and are given off segmentally to the blood-vessels Peripheral nerve block causes an increase in temperature of the innervated limb because the vasoconstrictors are paralyzed as well as the motor and sensory nerves

DeTakáts recommends peripheral nerve block and diathermy, both of which can be carried out on ambulatory patients A Tycos skin thermometer is used The test requires about fifteen minutes It consists in taking the skin temperature of the big toe on the plantar side and then producing a novocain block of the posterior tibial nerve White used sciatic block to determine the amount of vessel spasm in the lower extremity Both paravertebral block and posterior splanchnic anesthesia are attended by certain dangers

Scott and Morton found that the common vascular lesions in the extremities involve chiefly the feet, and that the most marked spasm and the most severe circulatory disturbances are usually manifested first in the toes The posterior tibial nerve furnishes the cutaneous innervation of the sole of the foot and the plantar surface of the toes It is ideal for providing the data desired concerning the results of nerve block After the level of the surface temperature has been established, the posterior tibial nerve is blocked just below the internal malleolus by injecting from 8 to 10 cc of a 1 per cent procain solution about it The nerve is followed forward from just behind the lower part of the external malleolus as far as it can be easily palpated, usually to a point about 2 cm directly beneath the posterior border of the malleolus, and the injection made at that point The nerve is immobilized by hooking the finger under it The point of the needle must be under the deep fascia, in the same compartment with the nerve It is not desirable to inject the procain into the nerve itself Loss of tactile sensation in the area of distribution begins within fifteen minutes Complete regional anesthesia to touch must be obtained If the surface temperature of the toe has gone up to or beyond 30 5° C (86 9° F), vasoconstrictor spasm is the cause of the local circulatory deficiency

If there is no increase in the temperature following the nerve block, vasoconstriction plays no rôle in the vascular lesion.

21. Brooks' intra-arterial sodium iodide test consists of the arterial injection of a solution of sodium iodide followed by roentgenography. According to Carnett and Greenbaum, 6 cc. of iodized oil may be injected into the femoral artery of the average man with safety.

22. Tobacco Test: The test of sensitivity to nicotine should be made in the case of every smoker.

Arteriography-vasography.—Allen and Camp found that thorium dioxide solution has the desired opacity, and when used in amounts of from 8 to 10 cc. produces no injurious effect. They consider thorotrast the ideal medium. Uroselectan may be employed. Arteriography seems to offer the most consistent information in cases of thromboangiitis obliterans.

Lewin Test Point.—The author wishes to call attention to a sign which he has noted in many cases of circulatory disturbances of the extremities, *viz.*, tenderness of a spot in the calf which is at the crux of the Y formed by the two bellies of the gastrocnemius muscle. It is near the fibrous arch of the soleus.

I have a theory that in certain cases of peripheral vascular lesions there is a fibrosis or "bottle neck" at the upper border of the calf at the junction of the two heads of the gastrocnemius where the soleus is found. I believe that this may be caused by prolonged intermittent pressure such as occurs in sitting with the legs crossed, and that it decreases the lumina of the blood-vessels and is responsible for some of the intermittent claudication associated with peripheral vascular lesions. There is a vicious cycle, the components of which are ischemia and necrosis. It should be investigated by a study of amputated limbs or necropsy material. As no one person sees a sufficient number of cases of peripheral vascular lesions to come to a conclusion, the work should be done at several surgical centers. The best cases for investigation are those in which amputation is unavoidable and those in which an exploration of the area described would not subject the patient to serious jeopardy. In the author's opinion this condition is analogous to DeQuervain's stenosing tenosynovitis at the wrist. I have felt that an exploratory operation under local anesthesia at the upper border of the calf in the mid-line would be beneficial in some cases of intermittent claudication.

Intermittent Claudication.—Intermittent claudication is caused by arterial spasm. It is characterized by pain, paresthesia, ache, cramp, spasm, or extreme fatigue. It occurs especially in the calf muscles after a certain amount of exercise and is relieved only by rest.

If activity is continued, spasticity, weakness and cramping are added to the pain. The pain is relieved in a few minutes by rest.

According to Mayo, the amount of muscular effort necessary to produce intermittent claudication is remarkably constant during any given stage of occlusive arterial disease This period has been called by Barker *et al* the "claudication time" (I suggest the term "claudication distance")

Intermittent claudication is one of the most constant signs of ischemia of muscles It may develop in the course of arteriosclerosis, thrombo-angiitis obliterans, traumatic arterial diseases, aneurysms, syphilitic arteritis, periarteritis nodosa, and acute arthritis It is an early warning of threatening gangrene Contributing factors include excessive use of condiments, overexertion, traumas, infections, exposure to cold, and especially nicotine Nearly all persons developing intermittent claudication are smokers and sensitive to nicotine Intermittent claudication is often erroneously diagnosed as flat-foot, neuritis, rheumatism, gout, varicose veins, or periostitis The prognosis should always be guarded

Occasionally irradiation of the vessels of the lower portion of the back or of the suprarenals is effective The value of galvanization and short-wave therapy is undetermined Sympathectomy is justifiable in refractory cases or when gangrene threatens

Buerger describes a paradoxical intermittent claudication Ischemia with subsequent hyperemia, or even stasis may affect the sensory nerves Distress at night may be due to the lack of movement with resulting stasis

Intermittent claudication should be considered a symptom rather than a disease There is a neurocirculatory element underlying the condition, possibly located in the sympathetic nerves The myalgia is secondary The muscle hypertonicity and the neurocirculatory disturbance create a vicious circle In addition to roentgenograms of the feet and legs, a careful examination should be made for mechanical defects of the feet, such as flat-foot, metatarsal arch depression, short plantar fascia, and a short Achilles tendon

Veal analyzed the vascular changes demonstrated by arteriography in 41 cases in which intermittent claudication was the predominant symptom and the basic vascular pathologic change was arteriosclerosis The abnormality common to all of these cases was obstruction of the small muscular branches with their fine terminal twigs The obliterative process may affect all of the muscles of the extremity, a single muscle, or an isolated portion of a muscle

Differential Diagnosis—The most important consideration is whether the condition is occlusive or spastic Some writers consider that if the pulse is present, the lesion is vasomotor, whereas if the pulse is absent, it is occlusive Brown found that the severity of trophic lesions or gangrene is more pronounced in obstructive lesions of the

arteries than in vasospastic disturbances. The most valuable observations are the amount of pain, the changes in appearance with a shift in position, the rate of capillary return after blanching, pulsation in the peripheral vessels, oscillometric readings, and the presence of gangrene.

Morton found the criteria of circulatory inefficiency to be symptomatic disturbances of function, *i. e.*, cramp-like pains and fatigue on using the involved limb; the color changes of congestion, ischemia, or cyanosis localized to the affected area; temperature changes; changes in the pulsation of the arteries; and delay in the return of color on pressure-blanching.

According to Brown and Henderson, confusion in the differential diagnosis is due largely to failure to make the fundamental distinction between functional or vasomotor and organic or obliterative lesions.

Mayo recognized the following four types of pain in occlusive arterial disease of the extremities: (1) the pain of acute arteritis, which is usually of relatively short duration and localized to the site of the arterial lesion; (2) the so-called "rest pain" of tissue necrosis, which is associated with marked regional ischemia, ulceration, gangrene, or secondary infection in ischemic regions; (3) the pain of ischemic neuritis, which is paroxysmal; and (4) the pain of intermittent claudication.

Morton and Scott point out that the majority of tests indicate only the adequacy or failing of the circulation. The color of the extremity in the horizontal, dependent, and almost vertical positions and after exercise is important. The time of color return after pressure has blanched an area indicates the efficacy of capillary circulation. The blushing test following the removal of a tourniquet often indicates fairly accurately the level below which the limb is in danger. The oscillometer may show that pulsation is still present when it can no longer be palpated. Saline solution intradermic wheals indicate the degree of circulatory impairment. The measurement of surface temperatures by thermocouple readings and the rapidity of return of such temperatures after the release of constriction of the circulation give data of value. The relative degree of vasoconstriction is shown by the intravenous typhoid vaccine reaction.

Arteriograms are helpful in determining the level of occlusion, but, as a rule it is wise to go high at the first operation to obviate the need for a second amputation because of failure of the stump to heal.

In arterial occlusion there is either spasm or an organic lesion or a combination of the two.

In their advanced stages, little difficulty is encountered in differentiating Raynaud's from Buerger's disease. In their early stages there may be difficulty. Raynaud's disease occurs almost exclusively in the female, and thrombo-angiitis almost exclusively in the male. Thrombo-

angiitis occurs most frequently in the feet. As a rule it is ushered in by pain or abnormal fatigue in the peroneal or anterior tibial muscles or the arch of the foot. The symptoms are usually first ascribed to either flat-foot or rheumatism. Somewhat later, intermittent claudication or muscular cramp is brought on by uninterrupted exercise but is readily relieved by rest. Still later, pain may be present even during rest.

In thrombo-angiitis, the obliteration is organic and leads to a decrease of pulsation in the peripheral vessels, particularly the dorsalis pedis. Vasospasm or angiospasm of a functional nature is sometimes superimposed. Thrombo-angiitis is frequent in excessive smokers. It is benefited by vascular postural exercises, control of walking and the use of vaccines and heat. The success of surgical procedures depends upon the extent of the functional element superimposed on the organic occlusion. The operation of choice is sympathetic ganglionectomy.

Raynaud's disease is much more frequent in the hands than in the feet. It is characterized by a peripheral cyanosis coming on with exposure to cold. Continued or extreme exposure leads to blanching or to rubor, the parts exhibiting two or three color-phase changes. As a rule, pulsation in the vessel is felt readily. The involvement tends to be symmetrical. In warm weather the patient is usually well. Attacks of severe pain are precipitated by cold. Gangrene occurs only in the end-stages. The angiospasm is chiefly functional, true organic occlusion being absent.

Prognosis.—The treatment of gangrene due to peripheral vascular diseases is becoming more conservative. The early institution of treatment reduces the frequency of the necessity for amputation.

Treatment.—Treatment may be divided into recumbent and ambulatory measures. The most important routine considerations are rest, elevation, and heat. Also to be recommended are: (1) absolute rest in bed for a short period, (2) immediate and complete abandonment of smoking, (3) reduction of the intake of meat, fish, eggs, sweets, and carbohydrates, (4) reduction of the weight, if indicated, (5) the drinking of from 1 to 4 quarts of Gerolsteiner or Kalak water with the juice of citrus fruit between meals and at bedtime, (6) Buerger's postural exercises, (7) massage of the feet twice daily, (8) treatment of the feet and legs with contrast sprays twice daily, and (9) exercises for the longitudinal and transverse arches.

General hygienic measures include: (1) improvement of the posture of the body, leg, and foot, (2) frequent short walks with a gradual increase in the distance and frequent rest periods, and (3) proper shoes (including heels, soles and linings) modified as required. Longitudinal and metatarsal pads in the shoes may be indicated. Fleece-, wool-, fur-, or felt-lined shoes may be advisable.

Treatment should be given for any associated condition such as diabetes, nephritis, syphilis or hypertension.

Treatment may be divided into: (1) symptomatic, (2) tonic, (3) local, (4) Pavaex, (5) intravenous, and (6) operative treatment. Systemic treatment consists mainly in prescribing prostigmine in small doses (15 mgm. two or three times daily). Often this will give dramatic relief and prolong claudication time sufficiently that no other measures need be taken. Tonic treatment includes the use of arsenic, iodides, phosphorus, and strychnine. In local treatment, the use of resilient felt to support the longitudinal and transverse arches should be given a trial. Special exercises for the supporting structures of the longitudinal and the transverse arches are also indicated. Gentle massage with an anodyne ointment consisting of equal parts of an anodyne lotion and cold cream or imadyl may be of value. Contrast sprays should be tried. Elevation of the feet for a period of from fifteen to forty-five minutes in the morning and afternoon is of value. Leg exercises in the recumbent position are helpful. Pavaex treatment is alternating constriction and release of the involved part. Intravenous injection of a protein substance produces a fever reaction which is often beneficial. Sympathetic nerve operations are of value in some cases.

As most patients with peripheral vascular lesions complain of painful feet, rigid arch supports are often erroneously prescribed. Modification of the shoes and the insertion of resilient supports are preferable.

The requirements in the treatment of organic occlusions of peripheral blood-vessels are given by DeTakáts as: (1) efforts to increase the collateral circulation; (2) efforts to alleviate pain; and (3) the removal of gangrenous parts at proper circulatory levels. In early cases, circulatory impairment may be relieved and the progress of the disease arrested. In complete vascular occlusion with inadequate collateral circulation all of the measures cited may fail completely. For relief of the excruciating pain in advanced cases, morphine is frequently employed. Desensitization of the foot by injection of the peripheral nerves with alcohol has been advocated by Smithwick and White.

The treatment of spastic occlusions aims to overcome spasm. Heat in any form will relieve a local spasm temporarily. Diathermy, electric bakers, and whirlpool baths are beneficial in mild cases. In young girls with cold hands and feet, chapped dry skin, and chilblains the metabolic rate is often low and the circulation is greatly improved by thyroid therapy. More severe, continuous spasms which are progressive and lead to symmetrical gangrene are treated by sympathetic ganglionectomy.

For the relief of severe pain accompanying ulceration and gangrene of the feet, Perlow recommends alcohol block of peripheral nerves

Theis concluded that, in the presence of functionally active arterial collaterals, appropriate sympathetic neurectomy produces an immediate increase in the peripheral circulation

Interest in the therapeutic use of various tissue extracts was stimulated by Frey and Kraut who isolated from urine a substance called "padutin" which was found to inhibit the pain of intermittent claudication when administered intramuscularly Frey believed the active agent to be a hormone present in many tissues but elaborated in the pancreas Other investigators have described extracts of pancreatic tissue which gave therapeutically similar results J S Schwarzmann prepared an extract of skeletal muscle which he called "myoston" The effect on tolerance to exercise was attributed to vasodilatation Barker, Brown, and Roth found pancreatic tissue extract to be the only substance with a definite and striking effect on the symptoms of intermittent claudication Its use in thrombo-angiitis obliterans and arteriosclerosis of the extremities should be restricted to cases in which intermittent claudication is the most prominent and distressing symptom

Recently, prostigmine has been found to be of great value It has a direct effect on the sympathetic nerve endings in the blood vessels and causes vasodilatation very satisfactorily

Claudication Time Test —The Barker, Brown, and Roth test is as follows After a rest of one-half hour, the patient walks on a level floor, with the doctor as the pacemaker, at the rate of 120 steps per minute until distress causes him to stop The time that elapses from the beginning of the walk until he stops is designated as the "claudication time"

Of a series of 55 cases of thrombo-angiitis obliterans and arteriosclerosis obliterans in which intramuscular injections of pancreatic tissue extract were given, the time necessary to produce intermittent claudication during a standard claudication test was found to be definitely lengthened after the injections in 92 per cent Similar effects were noted in all of a series of 8 cases of thrombo-angiitis obliterans after the intramuscular injection of myoston In 75 per cent of a series of 8 cases of intermittent claudication in which myoston was given orally, the effect was approximately the same, but more transient Definite increases in the claudication time were noted also in 4 cases in which muscle adenosin phosphoric acid was given intramuscularly and 4 cases in which adenosin was given intramuscularly

The Vasodilating Effects of Ethyl Alcohol —Cook and Brown found that alcohol gives many arteriosclerotic patients great relief, it occasionally helps to tide them over episodes of pain, and frequently delays amputation or renders it unnecessary Derivatives of opium are less effective than alcohol against the severe rest-pain of thrombo-angiitis

obliterans and arteriosclerotic disease. It has been found that alcohol given at the onset of the period of shivering after the administration of a foreign protein for disease of the peripheral blood-vessels either completely prevents subjective chilling or reduces its severity.

One of the most trying features connected with blood-vessel disorders of the extremities is a break in the morale due to the prolonged suffering. The continued use of avertin is sometimes helpful. Acetyl beta-methylcholine seems to be a promising drug for use in peripheral vascular disease because of its vasodilating effect, its safety, the ease of its administration, and its prolonged action. Mayo used acetylcholine in some cases of arteriosclerosis of the extremities of old or debilitated patients.

Special Instructions for Vascular Board.—Use an ironing board or table board. Place the board on the bed so that there will be plenty of room for the body. Elevate the lower or footboard end of the board to an angle of 45 degrees. As a prop, use the foot of the bed, a stool, a chair on its side, the legs of the ironing board, a store box, or a home-made prop. Instruct the patient as follows:

1. Lie on the bed with the legs flat on the bed, beside the board.
2. Place the thighs and legs on the board for five minutes.
3. Quickly swing the legs over the side of the bed and sit up for five minutes.
4. Lie flat on the bed with the legs beside the board for five minutes.
5. Repeat exactly three more times for one treatment period.

Hermann and Reid's Pavaex apparatus consists of a control box and a "treatment chamber" in the form of a boot made of pyrex glass. The end of the glass boot is fitted with a soft rubber cuff which can be adjusted to fit snugly around the thigh without obstructing the return of venous blood. As the treatment boot is transparent, color changes in the extremity during the treatment can be observed. The control box houses all the mechanical and electrical equipment necessary for the automaticity of the alternation of pressures, together with a mechanical means of providing a constant source of suction and pressure.

Sanders' Oscillating Bed in Peripheral Occlusive Arterial Disease.—The oscillating bed for the treatment of cardiovascular diseases was first described by Sanders in 1936. Such a bed has recently been accepted by the Council on Physical Therapy of the American Medical Association. It consists of a hospital bed attached to a special cradle so that the bed can be rocked on a transverse axis after the manner of a child's teeter. The power from an electric motor tips the bed slowly up and down through an arc of approximately 60 degrees at a

slow, regular rate The period of oscillation can be adjusted to take from one to seven minutes for a complete cycle

The recent researches of Barr and his associates indicate a wider usefulness of the apparatus in regard to nitrogen and calcium balances and calculus formation in such conditions as paraplegia, poliomyelitis, fractures, etc

Sheard devised a bed using the same principle but with a different type of mechanism The foot of Sheard's bed is raised and lowered through a fixed arc more rapidly but intermittently, the movement stopping at the maximal elevation and maximal dependency for certain periods which can be varied from a few seconds to several minutes

The principle of treatment with the oscillating bed according to Barker is the principle of postural exercises except that the changes in posture can be repeated for long periods and without physical effort on the part of the patient Physiological effects of treatment with the beds consisted of (1) the definite rhythmic changes in color of the feet and toes, namely, pallor on elevation and rubor on dependency indicating alternate filling and emptying of the capillary bed, (2) rather striking and rapid relief of pain of vascular origin in a large number of cases during the time that the patients were on the beds, (3) the induction of sleep in a large number of cases, even among patients who had great difficulty in sleeping for a period of time (this may be partially due to relief of pain), and (4) definite but incomplete vasodilation as evidenced by rise in the skin temperature of the digits

It is advisable to adjust the position and duration of the cycle for each patient so that the feet show blanching when elevated and rubor when dependent for a few seconds only The treatment can be combined with warm environmental temperatures any type of oral or intravenous therapy, artificial fever and, if desirable, can be alternated with other types of mechanical treatment such as intermittent suction and pressure

Buerger's Exercises —Buerger suggested the following exercises to increase the blood supply

With the patient lying in bed, the affected limb is elevated to from 60 to 90 degrees above the horizontal and rested in that position upon a support for from thirty seconds to three minutes, the period of time being the minimum amount necessary to produce blanching or ischemia As soon as blanching is established, the foot is allowed to hang down over the edge of the bed for from two to five minutes, until hyperemia appears, the total period of time being about one minute longer than that necessary to establish a good red color The limb is then placed in the horizontal position for from three to five minutes, during which

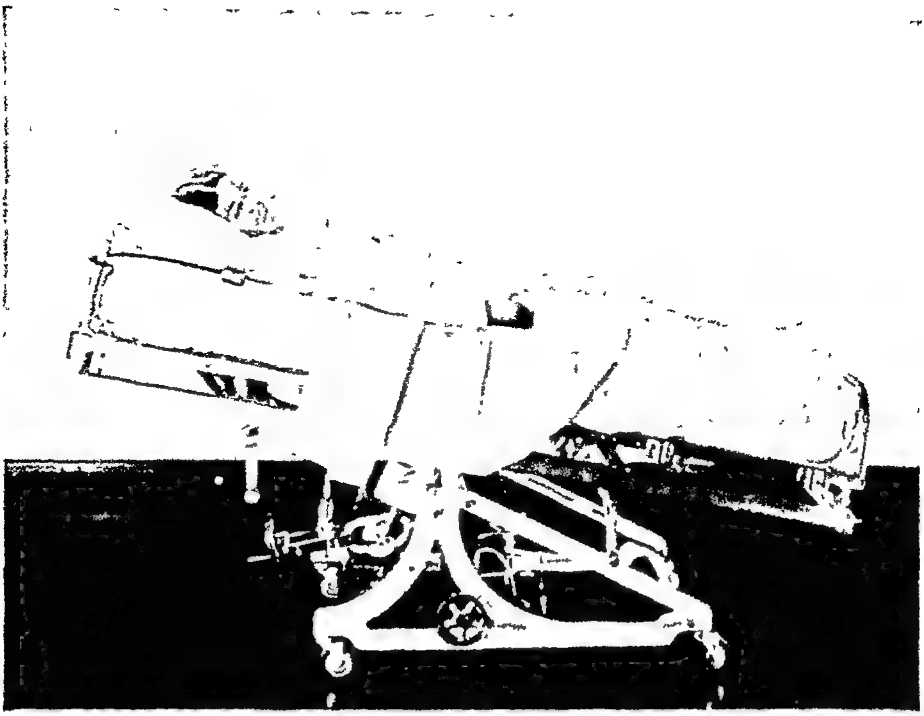


Fig. 320

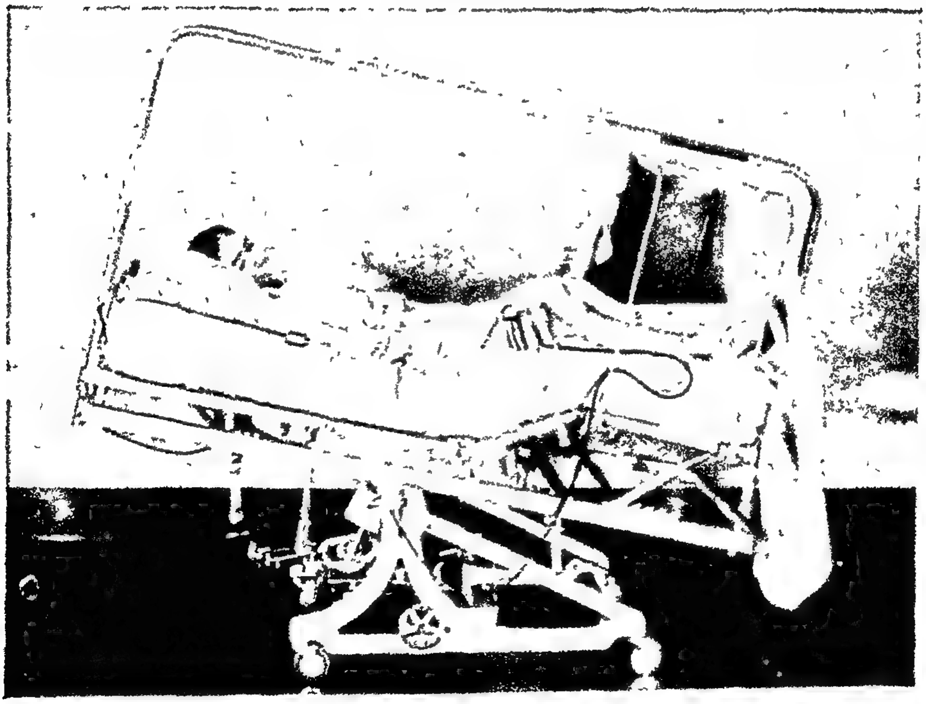


Fig. 321

Figs. 320 and 321.—Two views of the oscillating bed designed by Sanders, used in the treatment of peripheral vascular lesions. *(Courtesy of American Hospital Supply Corporation.)*

time an electric heating pad or a hot-water bag is applied The placing of the limb in these three successive positions constitutes a cycle, the duration of which is usually from five to ten minutes. The cycles are repeated over a period of about one hour every alternate hour of the day (Fig 323) During the hours of rest, heat is applied continuously

Operation on Sympathetic Nerves —Davis and Kanavel state that the peripheral blood-vessels receive their sympathetic innervation in a segmental manner by way of the somatic nerves Removal of the sympathetic innervation to an extremity is followed by hyperemia and hyperthermia which gradually disappear within from one to two weeks In certain vascular diseases of the extremities characterized by paroxysmal vasomotor symptoms and the absence of organic changes in the vessels, removal of the sympathetic innervation is followed by improvement in the symptoms In this group are included erythromelalgia and Raynaud's disease

Sympathetic ganglionectomy of L_2, L_4 and L_5 is now the accepted procedure in most cases It is an interesting comment that Royle's original approach to the cervical sympathetic chain was anterior and to the lumbars was postero-lateral ("Kidney incision") At present the consensus of leading surgeons is to approach the cervicals from behind and the lumbars from the antero-lateral location

ARTERIOSCLEROSIS

There are two forms of arteriosclerosis, namely, the arteriosclerosis of old age, due to wear and tear, with local calcified areas, and the arteriosclerosis which is a constitutional systemic condition of the smooth muscles, the sympathetic nerves, and the connective tissue substance in the vascular walls The primary cause of arteriosclerosis is weakening of both the muscular and the elastic elements of the vascular walls Calcium may be removed from the bones and deposited in the blood-vessels

Calcification of blood-vessels may be due to senility, strain, lead poisoning, overeating, gout, syphilis, alcoholism, nephritis, or diabetes

The incidence of vascular calcification increases with age and with the duration of disease It is higher in diabetic than in non-diabetic persons

Prolonged standing tires the vasomotor nerves, causing the feet to swell It involves both the venous and the lymphatic circulations Swelling is less marked if exercise is taken The speed of the circulation depends to a considerable degree upon the viscosity of the blood The circulation may be so impaired in the feet that gangrene develops

Treatment.—For the treatment of arteriosclerosis, Buerger recommends: (1) postural exercises (Fig. 323); (2) hot air treatment; (3) diathermy; (4) the heat of electric lamps; and (5) the thermophore.

Vein Ligation in the Treatment of Arteriosclerotic and Diabetic Gangrene.—Vein ligation has been employed by Pearce in the treatment of obliterative vascular disease of the lower extremity for the past seveial years. The beneficial effects are a subjective sensation of warmth, diminution of the pain, acceleration of healing of the local lesion, an increase in the rate of return of the circulation after blanching, improvement in the color of the extremity, and an increase in the temperature of the part. When done in suitable cases, vein ligation often definitely improves the peripheral circulation.

The indications for vein ligation in the treatment of arteriosclerotic and diabetic gangrene are impending gangrene, in the absence of a break in the continuity of the skin; absence of peripheral pulses below the popliteal artery, and excruciating pain both after exercise and at rest.

Before insulin was available, diabetic gangrene often demanded amputation to save life, but today, it is possible to control the diabetic state and to use conservative surgical measures.

Reichert relieved intermittent claudication in arteriosclerotic patients by interrupting the sympathetic pathways, by the paravertebral injection of alcohol following the diagnostic use of novocain.

Wirtschafter uses histidine and vitamin C.

THROMBO-ANGIITIS OBLITERANS (BUERGER'S DISEASE)

The most important circulatory disturbance of the extremities from the orthopædic standpoint is a lesion described by von Winiwarter in 1878 as "endarteritis obliterans," and by Buerger in 1908 as "thrombo-angiitis obliterans." It is characterized by spasmodic pain in the leg, especially in the calf and foot, and intermittent claudication. The condition is found most commonly in Russians, Poles, and Galicians, and is especially frequent in heavy smokers. Thrombo-angiitis obliterans is due to a progressive thrombotic occlusion of the arteries alone or of the arteries and veins. The subjective manifestations are pain and intermittent claudication, and the objective phenomena are redness when the limb is in the dependent position, marked blanching when it is in the elevated position, absence of pulsation of the vessels, and trophic disturbances often terminating in gangrene.

Etiology.—Heredity, race, sex, worry, metabolic disturbances, and tobacco are etiological factors. The disease occurs almost exclusively in males. There appears to be a sex-linked hereditary element in its development. The use of tobacco is an important factor. The constitutional factor is inherited.

Thrombo-angiitis usually affects men between the ages of twenty and forty-five years. Of approximately 700 patients whose cases were reviewed by Horton and Brown 10 were women. The average age was thirty-nine years. Four of the 10 women used cigarettes excessively.

Ninety-one per cent of the patients with thrombo-angiitis obliterans observed by Barker used cigarettes, as compared with 56 per cent in a control group. A few never used tobacco in any form. Osterberg found that 1 cigar is equal to 8 or 10 cigarettes. Therefore a man smoking from 10 to 12 cigars a day would smoke the equivalent of from 100 to 200 cigarettes. Yet thrombo-angiitis obliterans is rare in cigar or pipe smokers.

W. J. Mayo says that "pipe smoking should be the least harmful because the pipe is usually out and the smoker is usually just as happy until he notices that fact. The pipe seems to be the adult pacifier which takes the smoker back to his childhood days." There is evidence that in many cases tobacco or cigarette smoking augments the syndrome and hastens the pathological changes. An injury may excite the condition and result in a premature loss of a part.

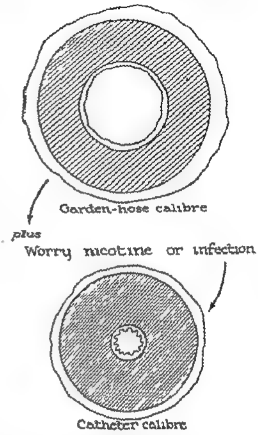


FIG. 322.—Illustrating the change in volume and caliber of an artery affected by thrombo-angiitis obliterans (highly diagrammatic).

Pathology.—Thrombo-angiitis obliterans produces inflammation of the blood-vessel walls. There may be an accompanying arteriosclerosis.

In the early stages of the process, a thrombus develops which undergoes organization or healing with ultimate complete occlusion of the affected vessels. Robertson found a definite preganglionitis.

Barker estimated that superficial phlebitis occurs in from 40 to 50 per cent of the cases. Adson found that Buerger's disease is often bilateral.

Signs and Symptoms.—The most characteristic sign is intermittent claudication in the calf. The pain called "rest-pain" may be in the longitudinal arch or the heel. Rubor in the dependent position and pallor in the elevated position are significant.

Pain is due to the demand of the dying tissues for oxygen.

Brown states that the first symptoms noticed in the extremities are claudication, weakness, fatigue, and cramps or pain which appear in a certain muscle group after a certain amount of walking and are immediately relieved after cessation of the exercise. The length of the walk necessary to produce these characteristic symptoms gives a definite clue as to the degree of arterial occlusion present. If walking of three or four blocks produces distress in the muscles of the calf, the closure of at least one large artery may be assumed. Intermittent claudication is most marked when the patient is walking. The toes and feet are cold and often moist, and in the dependent position are usually discolored. Samuels believes that plantar ischemia is an important early diagnostic sign. Redness in the dependent position is striking. Subjective symptoms are intense pain in the toes and feet, sometimes extending up the leg and increasing at night to the point of preventing sleep. To obtain sleep, the patient may be obliged to hang his feet out of the bed or to sit up in a chair. As the pressure of the shoe increases the pain, many patients wear soft, felt shoes or swathe the foot in flannel.

The objective findings are as follows: The patient walks with a gait like that of the person with painful flat-feet. The feet appear blue and congested, but pressure by the hand and manipulation of the feet elicit little pain. Sensitiveness to heat and cold is diminished. The skin has a clammy, cadaverous feeling. The pulsation in the dorsalis pedis and the posterior tibial arteries is either absent or diminished. The pain is less severe in warm weather. The symptoms may extend over a period of months or years. In severe cases there is atrophy of one or more toes characterized by darkening of the skin with a dry gangrenous appearance, but differing from other forms of gangrene in the slowness of its progress.

Prognosis.—Horton and Brown found that if the intervals between relapses are short and the time of adequate circulation is brief, trophic changes terminating in gangrene are likely to ensue. They found that from 20 to 30 per cent of patients lose one or more limbs.

Barker and Brown concluded that in 60 per cent of the cases, gangrene has been initiated by meddlesome procedures on a sore toe or finger. If the simple procedure of palpating the arteries of the hands and feet were carried out routinely in examinations of the extremities, the incidence of gangrene would be sharply reduced.

Treatment.—The [illegible] ent includes general, local, and focal measures, negative an[illegible] re[illegible] ccines, operations on arteries, nerve injection, s[illegible] ns, and amputation.

Diagnosis of t[illegible] n. nce of gangrene, more judicious handlin[illegible] ities, and education of

patients will lessen the need for amputation of extremities Amputation can be carried out below the knee with healing in more than 80 per cent of cases

The general treatment includes rest in bed for mental and physical relaxation Focal infections must be investigated and removed if possible Medicinal treatment is indicated to relieve pain and dilate the blood-vessels For the latter purpose, nitrites are used with erythrol tetranitrate, benzyl benzoate, and potassium iodide Theobromine salicylate (diuretin) should be tried If sleep is disturbed, luminal may be added Fluids by mouth must be given very freely The use of Kalak or Gerolsteiner water up to 2 or 3 quarts per day, is indicated The diet should be limited so far as meat, fish, eggs, and carbohydrates are concerned Heliotherapy is indicated, and mental therapy is often required Tobacco, alcohol, and worry should be avoided

The local treatment includes absolute rest in bed The limb should be higher than the rest of the body External applications of dry or moist heat are advised Massage is contraindicated Diathermy applied locally and to the lumbar sympathetics is of value Ultra-violet irradiation is of some value in early cases Negative pressure obtained with a vacuum is beneficial The Hermann-Reid (Pavaex) apparatus have been effective The Sanders' bed is helpful Hyperemia and active congestion have a good effect Local infection must be treated Lewis and Reichert improve the collateral circulation by ligating the femoral artery The effect of this is enhanced by simultaneous venous ligation Buerger's exercises, and contrast sprays or plunges are beneficial

Allen prescribes exercises in three groups (1) elevation of the legs at an angle of 45 degrees for two minutes, (2) feet hanging over the bed for three minutes, (3) legs horizontal for five minutes (Fig 323) He believes that routine treatment is more valuable than any specific measure He recommends the Balkan frame, aspirin, barbituric derivatives, typhoid vaccine, alcohol injection, and compression of the posterior tibial nerve with a hemostat

When the disease is well developed, it is advisable for the patient to remain in bed for several weeks or at least refrain completely from walking and standing Therapeutic measures should be directed toward the conservation of warmth, improvement of the circulation, the prevention of traumatism, and the treatment of trophic disorders or gangrene when these supervene Numerous authorities have obtained their best results with non-specific foreign protein In some cases it is necessary to amputate toes, feet, legs, or thighs

As general measures, Adson recommends avoidance of trauma and exposure to cold and a change of occupation which will relieve the patient of the necessity of standing Hospitalization is very important

Brown states that the first symptoms noticed in the extremities are claudication, weakness, fatigue, and cramps or pain which appear in a certain muscle group after a certain amount of walking and are immediately relieved after cessation of the exercise. The length of the walk necessary to produce these characteristic symptoms gives a definite clue as to the degree of arterial occlusion present. If walking of three or four blocks produces distress in the muscles of the calf, the closure of at least one large artery may be assumed. Intermittent claudication is most marked when the patient is walking. The toes and feet are cold and often moist, and in the dependent position are usually discolored. Samuels believes that plantar ischemia is an important early diagnostic sign. Redness in the dependent position is striking. Subjective symptoms are intense pain in the toes and feet, sometimes extending up the leg and increasing at night to the point of preventing sleep. To obtain sleep, the patient may be obliged to hang his feet out of the bed or to sit up in a chair. As the pressure of the shoe increases the pain, many patients wear soft, felt shoes or swathe the foot in flannel.

The objective findings are as follows: The patient walks with a gait like that of the person with painful flat-feet. The feet appear blue and congested, but pressure by the hand and manipulation of the feet elicit little pain. Sensitiveness to heat and cold is diminished. The skin has a clammy, cadaverous feeling. The pulsation in the dorsalis pedis and the posterior tibial arteries is either absent or diminished. The pain is less severe in warm weather. The symptoms may extend over a period of months or years. In severe cases there is atrophy of one or more toes characterized by darkening of the skin with a dry gangrenous appearance, but differing from other forms of gangrene in the slowness of its progress.

Prognosis.—Horton and Brown found that if the intervals between relapses are short and the time of adequate circulation is brief, trophic changes terminating in gangrene are likely to ensue. They found that from 20 to 30 per cent of patients lose one or more limbs.

Barker and Brown concluded that in 60 per cent of the cases, gangrene has been initiated by meddlesome procedures on a sore toe or finger. If the simple procedure of palpating the arteries of the hands and feet were carried out routinely in examinations of the extremities, the incidence of gangrene would be sharply reduced.

Treatment.—The treatment includes general, local, and focal measures, negative and positive pressure, vaccines, operations on arteries, nerve injection, sympathetic nerve operations, and amputation.

Diagnosis of the disease before the appearance of gangrene, more judicious handling of devascularized extremities, and education of

patients will lessen the need for amputation of extremities Amputation can be carried out below the knee with healing in more than 80 per cent of cases

The general treatment includes rest in bed for mental and physical relaxation Focal infections must be investigated and removed if possible Medicinal treatment is indicated to relieve pain and dilate the blood-vessels For the latter purpose, nitrites are used with erythrol tetranitrate, benzyl benzoate, and potassium iodide Theobromine salicylate (diuretin) should be tried If sleep is disturbed, luminal may be added Fluids by mouth must be given very freely The use of Kalak or Gerolsteiner water up to 2 or 3 quarts per day, is indicated The diet should be limited so far as meat, fish, eggs, and carbohydrates are concerned Heliotherapy is indicated, and mental therapy is often required Tobacco, alcohol, and worry should be avoided

The local treatment includes absolute rest in bed The limb should be higher than the rest of the body External applications of dry or moist heat are advised Massage is contraindicated Diathermy applied locally and to the lumbar sympathetics is of value Ultra-violet irradiation is of some value in early cases Negative pressure obtained with a vacuum is beneficial The Hermann-Reid (Pavaex) apparatus have been effective The Sanders' bed is helpful Hyperemia and active congestion have a good effect Local infection must be treated Lewis and Reichert improve the collateral circulation by ligating the femoral artery The effect of this is enhanced by simultaneous venous ligation Buerger's exercises, and contrast sprays or plunges are beneficial

Allen prescribes exercises in three groups (1) elevation of the legs at an angle of 45 degrees for two minutes, (2) feet hanging over the bed for three minutes, (3) legs horizontal for five minutes (Fig 323) He believes that routine treatment is more valuable than any specific measure He recommends the Balkan frame, aspirin, barbituric derivatives, typhoid vaccine, alcohol injection, and compression of the posterior tibial nerve with a hemostat

When the disease is well developed, it is advisable for the patient to remain in bed for several weeks or at least refrain completely from walking and standing Therapeutic measures should be directed toward the conservation of warmth, improvement of the circulation, the prevention of traumatism, and the treatment of trophic disorders or gangrene when these supervene Numerous authorities have obtained their best results with non-specific foreign protein In some cases it is necessary to amputate toes, feet, legs, or thighs

As general measures, Adson recommends avoidance of trauma and exposure to cold and a change of occupation which will relieve the patient of the necessity of standing Hospitalization is very important

Large quantities of Ringer's, Locke's, or Meyer's solution may be given by mouth or by duodenal tube. Special comfortable soft-lined shoes are essential.

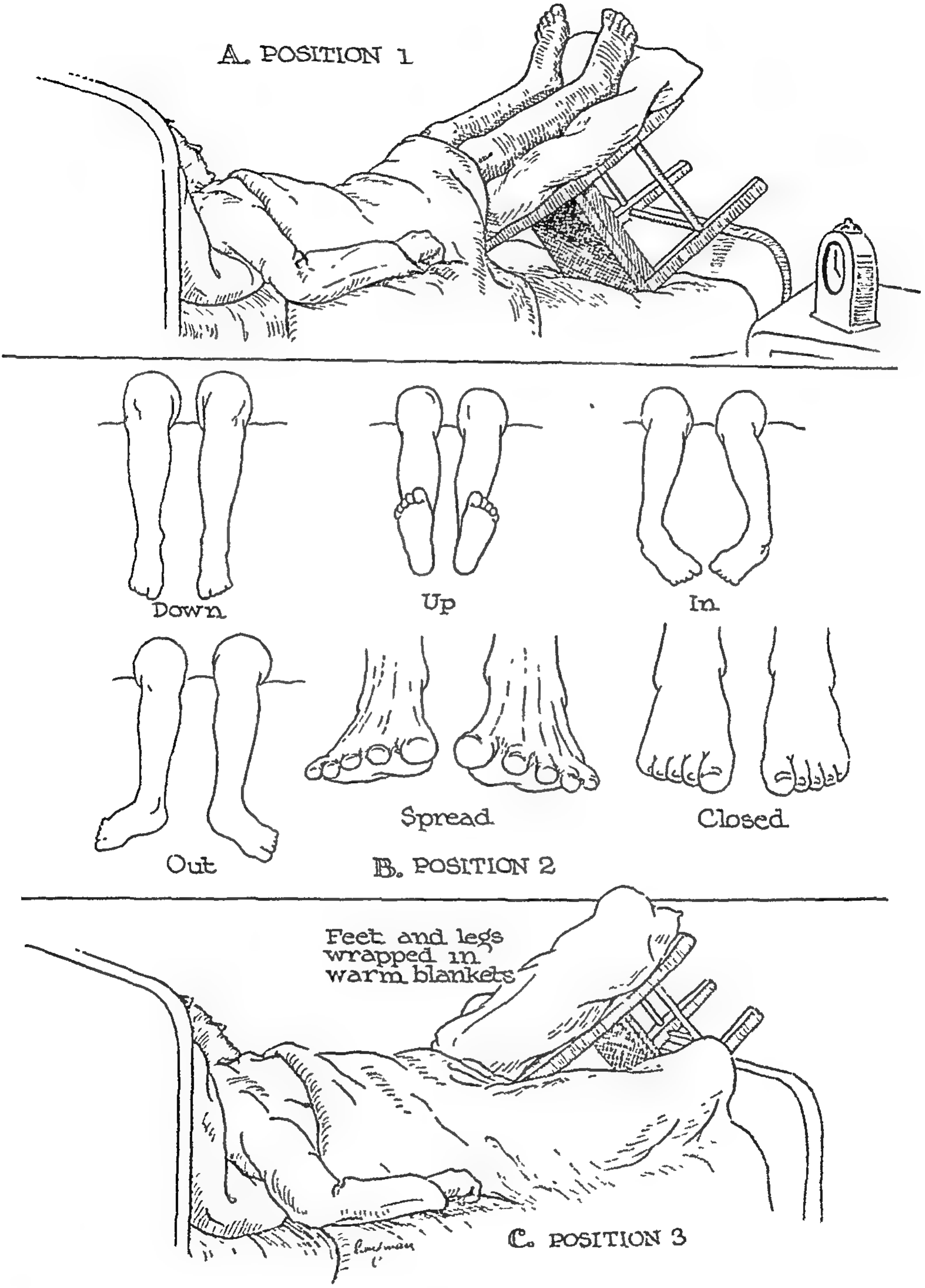


FIG. 323.—Sketch showing Buerger-Allen active vascular exercises After determining the number of minutes for each position, a diagram such as the one shown here is filled out and given to the patient. In position 3, the feet and legs should be wrapped in warm blankets. INSTRUCTIONS: Do these movements slowly and carefully. Position 1, two minutes; position 2, three minutes; position 3, five minutes Repeat it as often as directed (Adapted from Allen, courtesy of Ann Surg.)

For dilation of the vessels Frauenthal advised the oral administration of a 1 per cent solution of nitroglycerin in 1-drop doses before meals He believes that by this treatment about 65 per cent of patients can be saved from amputation Perlow has obtained excellent results with prostigmine given in small doses (15 mg three or four times daily)

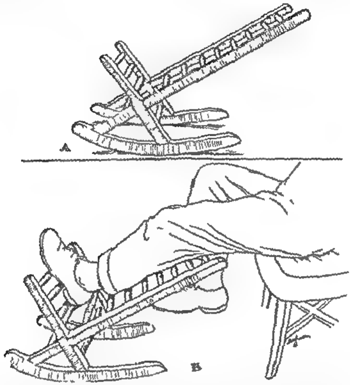


FIG 324 —Foot and leg elevator rocker This furnishes support comfort elevation and passive movements Rocker should be covered by blanket material

Samuels recommends the intravenous administration of hypertonic saline solution, the use of diathermy, hot sitz baths, and postural exercises Of the more than 300 cases which he has treated by conservative methods in the past several years, amputation of the leg was necessary in only one The affected limb must be maintained constantly in the horizontal position The injection of hypertonic sodium chloride solution intravenously should be started as soon as the diagnosis is made, and 300 cc should be given every other day until the gangrene and ulceration are healed The dead tissue must be kept as aseptic as possible and encouraged to slough Pain is never a valid indication for amputation As the gangrene is self-limited, amputation is indicated only when there is total destruction of the foot, rendering a weight-bearing stump unattainable without it In 70 per cent of cases pancreatic, skeletal, and heart muscle extracts increase tolerance to exercise to a significant degree

Bernheim suggested exercising the blood-vessels by alternately

plunging the foot into ice water and hot water, leaving the limb in the ice water for one or two seconds, then plunging it immediately into very hot water, and repeating this alternation for four or five minutes, ending with heat. This procedure is repeated three times a day. After each bath, the foot is dried, bathed in oil, and kept warm for an hour. Between the baths, an electric vibrator is used. After two or three weeks, the baths are taken twice daily. The discomfort associated with this treatment, may be controlled by the administration of codein or bromides. Morphine should not be employed.

Silbert and Friedlander found that patients with thrombo-angiitis obliterans have a low blood volume and a low basal metabolism, but that these can be raised to normal by the administration of thyroid extract.

Foreign Protein or Vaccine Therapy.—In 1923, Goodman and Gottesman proposed the use of foreign protein in the treatment of vascular diseases. According to Allen and Smithwick, non-specific foreign protein produces definite relief of the pain and improvement in the appearance of the lesions. Brown and Mahorner found that the injection of protein is followed by dilation of the collateral blood-vessels with an increase in the amount of blood in the diseased extremity and immediate relief of the pain in 60 per cent of the cases.

Roentgen Therapy.—Phillips and Tunick applied roentgen therapy to the spinal and paravertebral regions over the mid-anterior and posterior aspects of the body from the tenth thoracic to the fifth lumbar vertebræ. Zimmerman advised the application of roentgen-rays to the suprarenal capsules.

Sympathetic Nerve Operations.—In 1925 I suggested to Dr. Royle that lumbar sympathectomy should be beneficial in cases of thrombo-angiitis obliterans. Sympathetic nerve operations include periarterial sympathectomy, sympathetic ramisection, and trunk section. Allen prefers the ramisection of Royle to periarticular sympathectomy. Adson believes that Buerger's disease offers the largest field for sympathectomy. Periarterial sympathectomy is the surgical removal of the sympathetic fibers situated in the wall of an artery. In 1913, Leriche recommended this operation for vasomotor and trophic disturbances. Sistrunk recommended a routine bilateral operation.

In purely vasospastic disturbances, vasodilatation will result if the operation is complete. Arthritis and early cases of Raynaud's disease fall in this group. In arteriosclerosis obliterans, sympathetic ganglionectomy is inadvisable.

Sixty-seven cases of thrombo-angiitis obliterans were studied by Brown, Craig, and Adson to determine the prognostic value and the relation of the peripheral vasodilatation obtained with systemic fever to the increase of surface temperature following sympathetic ganglion-

ectomy Among the important factors to be considered in the selection of cases of this form of vascular disease for operation are the integrity of the coronary arteries, the rate of progression, the stage of the disease, and the ability to produce healing and relieve pain by medical measures About one-third of the cases are suitable for operation

The vasomotor gradient can be completely obliterated after spinal anesthesia

Chemical Exclusion of Sympathetic Nerve—Doppler recommends painting the artery with a 7 per cent solution of phenol, whereby the highly vulnerable fibers of the sympathetic nerve are so damaged that a marked vasodilatation results In arteriosclerotic spasm in the region of the femoral and tibial arteries rapid improvement was observed

Early recognition of thrombo-angiitis obliterans may prevent gangrene In 50 per cent of Brown and Henderson's cases, the irritating factor producing gangrene was meddlesome surgery of the toes

Amputation—The indications for amputation are impending or actual gangrene, uncontrollable pain, and sometimes mental symptoms Pain is not an absolute indication for amputation It is important to determine the proper level of operation, where the circulation is adequate for healing

The age and general condition of the patient and the condition of the tissues at the proposed operative site are important If no blanching occurs upon the injection of adrenalin into the muscle and skin, one may conclude that there is no circulation The oscillometer helps in the pre-operative determination of the level According to some, an amputation below the junction of the middle and lower thirds of the thigh is useless The technic must be perfect and the asepsis absolute

When the loss of the extremity is inevitable, the level at which amputation is to be done should receive careful consideration I cannot sufficiently stress the importance of saving the knee joint Most patients with thrombo-angiitis obliterans are young men who must continue to earn a livelihood Employers do not like to have obviously crippled men about them The man with an artificial leg fitted to a thigh stump walks with a very noticeable limp, whereas the man with an artificial leg fitted to a stump below the knee walks without a cane and with scarcely any limp

The incidence of major amputations was reduced to 6 4 per cent in Silbert's series of 687 patients treated conservatively

RAYNAUD'S DISEASE

In 1862, Raynaud summarized the clinical features of this condition as follows In slight cases the ends of the fingers and toes become cold, cyanosed, livid, and painful In grave cases, the cyanosis extends upward for several centimeters above the root of the nails At the

plunging the foot into ice water and hot water, leaving the limb in the ice water for one or two seconds, then plunging it immediately into very hot water, and repeating this alternation for four or five minutes, ending with heat. This procedure is repeated three times a day. After each bath, the foot is dried, bathed in oil, and kept warm for an hour. Between the baths, an electric vibrator is used. After two or three weeks, the baths are taken twice daily. The discomfort associated with this treatment, may be controlled by the administration of codein or bromides. Morphine should not be employed.

Silbert and Friedlander found that patients with thrombo-angiitis obliterans have a low blood volume and a low basal metabolism, but that these can be raised to normal by the administration of thyroid extract.

Foreign Protein or Vaccine Therapy.—In 1923, Goodman and Gottesman proposed the use of foreign protein in the treatment of vascular diseases. According to Allen and Smithwick, non-specific foreign protein produces definite relief of the pain and improvement in the appearance of the lesions. Brown and Mahorner found that the injection of protein is followed by dilation of the collateral blood-vessels with an increase in the amount of blood in the diseased extremity and immediate relief of the pain in 60 per cent of the cases.

Roentgen Therapy.—Phillips and Tunick applied roentgen therapy to the spinal and paravertebral regions over the mid-anterior and posterior aspects of the body from the tenth thoracic to the fifth lumbar vertebræ. Zimmerman advised the application of roentgen-rays to the suprarenal capsules.

Sympathetic Nerve Operations.—In 1925 I suggested to Dr. Royle that lumbar sympathectomy should be beneficial in cases of thrombo-angiitis obliterans. Sympathetic nerve operations include periarterial sympathectomy, sympathetic ramisection, and trunk section. Allen prefers the ramisection of Royle to periarticular sympathectomy. Adson believes that Buerger's disease offers the largest field for sympathectomy. Periarterial sympathectomy is the surgical removal of the sympathetic fibers situated in the wall of an artery. In 1913, Leriche recommended this operation for vasomotor and trophic disturbances. Sistrunk recommended a routine bilateral operation.

In purely vasospastic disturbances, vasodilatation will result if the operation is complete. Arthritis and early cases of Raynaud's disease fall in this group. In arteriosclerosis obliterans, sympathetic ganglionectomy is inadvisable.

Sixty-seven cases of thrombo-angiitis obliterans were studied by Brown, Craig, and Adson to determine the prognostic value and the relation of the peripheral vasodilatation obtained with systemic fever to the increase of surface temperature following sympathetic ganglion-

ectomy *Among the important factors to be considered in the selection of cases of this form of vascular disease for operation are* the integrity of the coronary arteries, the rate of progression the stage of the disease, and the ability to produce healing and relieve pain by medical measures About one-third of the cases are suitable for operation

The vasomotor gradient can be completely obliterated after spinal anesthesia

Chemical Exclusion of Sympathetic Nerve —Doppler recommends painting the artery with a 7 per cent solution of phenol, whereby the highly vulnerable fibers of the sympathetic nerve are so damaged that a marked vasodilatation results In arteriosclerotic spasm in the region of the femoral and tibial arteries rapid improvement was observed

Early recognition of thrombo-angiitis obliterans may prevent gangrene In 50 per cent of Brown and Henderson's cases, the irritating factor producing gangrene was meddlesome surgery of the toes

Amputation —The indications for amputation are impending or *actual gangrene, uncontrollable pain, and sometimes mental symptoms* Pain is not an absolute indication for amputation It is important to determine the proper level of operation, where the circulation is adequate for healing

The age and general condition of the patient and the condition of the tissues at the proposed operative site are important If no blanching occurs upon the injection of adrenalin into the muscle and skin, one may conclude that there is no circulation The oscillometer helps in the pre-operative determination of the level According to some, an amputation below the junction of the middle and lower thirds of the thigh is useless The technic must be perfect and the asepsis absolute

When the loss of the extremity is inevitable, the level at which amputation is to be done should receive careful consideration I cannot sufficiently stress the importance of saving the knee joint Most patients with thrombo-angiitis obliterans are young men who must continue to earn a livelihood Employers do not like to have obviously crippled men about them The man with an artificial leg fitted to a thigh stump walks with a very noticeable limp, whereas the man with an artificial leg fitted to a stump below the knee walks without a cane and with scarcely any limp

The incidence of major amputations was reduced to 6 4 per cent in Silbert's series of 687 patients treated conservatively

RAYNAUD'S DISEASE

In 1862, Raynaud summarized the clinical features of this condition as follows In slight cases the ends of the fingers and toes become cold, cyanosed, livid, and painful In grave cases, the cyanosis extends upward *for several centimeters above the root of the nails* At the

same time, the nose and ears may become the seat of analogous phenomena. Finally, if this state is prolonged, dry gangrenous areas appear on the extremities.

Brown and Adson agree with Raynaud that in early typical cases the lesion is in the sympathetic nervous system. Following complete interruption of nerve fibers by anesthetization or operation, there are no longer signs of Raynaud's disease in the denervated extremity. From a study of more than 150 cases, Allen and Brown formulate the following criteria for the diagnosis: (1) episodes of change in color of the vasospastic type, excited by cold or emotion, which usually precede the trophic changes by months or years; (2) symmetrical or bilateral involvement; (3) the presence of normal pulsations in the palpable arteries; (4) the absence of gangrene or its limitation to minimal grades of cutaneous gangrene; (5) the absence of a primary condition which might be causal, such as cervical rib or organic disease of the nervous system; and (6) symptoms with a duration of two years or longer.

Raynaud's phenomenon is usually bilateral. It is most common in females between the ages of twenty-eight and thirty-five years. When seen in children, syphilis should be suspected. The syndrome of Raynaud's disease is characterized by the absence of arterial occlusion; symmetry of involvement; gangrene of a minor nature; and intermittency of color changes.

The pathological changes in the sympathetic nervous system and the digital arteries are late manifestations.

Sir Thomas Lewis considers cyanosis rather than pallor to be characteristic, and believes that degenerative changes in the peripheral vessels are the primary cause of the attack. According to most observers, the attacks are due to reflex disturbances, and the changes in the vessels are secondary.

The climate should be temperate and the vocation should not require much weight-bearing. Cold bathing is contraindicated, but Kerr advised short exposures to extremes of cold. Proper shoes and woolen stockings should be worn. Metal plates are contraindicated. Cutting of any kind about the foot or toes should be avoided.

Klecan reported an excellent result following the administration of 2 gr. of anterior pituitary substance three times a day. Raynaud's disease of the lower extremities can usually be relieved by bilateral sympathetic ganglionectomy and ramisectomy of the second, third, and fourth lumbar segments.

ACRODYNIA

Acrodynia is characterized by red, painful palms and soles of the raw-beef type. It is also called "erythredema." Wyckoff con-

firms Byfield's claim that it is a peripheral neuritis involving mainly the sensory nerves and causing marked vasomotor disturbances of the extremities. Its symptoms are those of polyneuritis. There are burning pains in the palms and soles with severe hyperesthesia. The pain is accompanied by an erythematous rash which is most marked on the extremities and in some cases develops into an intense pigmentation. There is photophobia with increased lacrimation. In the adult the condition lasts about four weeks, in the young it lasts for from two to eighteen months. Nothing is known as to the cause or the pathological changes. Some consider acrodynia an infection, others an allergy, and still others an avitaminosis. Some remarkable results have followed the administration of crystalline vitamin B_1.

CHILBLAINS

Chilblains or pernio is a neurocirculatory disturbance of the skin of the feet. It is like trench foot but without the elements of constriction and dampness. It is due to exposure to severe cold below the point of freezing which is followed by rapid warming of the tissues.

Treatment with the melted paraffin wax bath was introduced by Littlewood during the latter part of the World War II. (This is of value also as a preliminary for massage.)

THE ANGIONEUROSES

According to Dnry and Moreau, the symptoms of angioneuroses may be divided into disorders of vascular contractility and capillary permeability. Disorders of the glands of internal secretion are often associated with vasomotor disturbances.

Modifications of vascular contractility occurring during angioneuroses may take the form of vasoconstriction or vasodilatation. The former, the angiospasm, is the basis of a number of vascular neuroses. Angiospasm plays an important part in the production of intermittent claudication. It is involved also in the Raynaud syndrome. Vasodilatation is traceable to excitation of the vasodilators that give rise to erythromelalgia and to abolition of the vasoconstrictive tonus that produces acrocyanosis. The causes and pathological changes in these neuroses are unknown. In all conditions in which paresthesia in the extremities is a symptom, it is necessary to exclude pernicious anemia, multiple sclerosis, and multiple peripheral neuritis. Some relief is secured from the local application of the faradic current. Because of the low metabolic rate, the administration of thyroid or pituitary extract has been suggested. The coal-tar derivatives are sometimes effective in relieving pain.

Emotions such as fear produce a decided effect on the vasomotor centers, resulting in constriction of the arterioles and rapid lowering of the temperature of the feet. Eustess, Ebbecke, and Lewis showed that flushing of the skin and wheal formations have a chemical basis. The release in the tissues of vasodilator substances from local physical effects explains the phenomena observed in cases of localized edema. In cases of hypersensitivity to cold, the application of cold produces massive swelling with evidence of vasodilation. In some cases a curious systemic reaction, consisting of flushing of the face, syncope, and a rapid pulse rate is exhibited.

A change in posture of the lower extremities alters the blood-pressure and the strength of the pulsation in the arteries of the limb. When the leg is in the dependent position, the systolic and diastolic pressures increase and the pulsation is maximal. Elevation of the limb produces the opposite effect, namely, a decrease in the blood-pressure and in the force of the pulse.

PERIARTERITIS NODOSA

Periarteritis nodosa may produce cramps in the extremities and pain in the skeletal muscles and along the course of the peripheral nerves suggesting neuritis, myositis, or trichinosis. The pathological change is an exudative inflammation of the periadventitial structures, the adventitia, the media, and sometimes the intima. According to Arkin, the condition is an inflammatory disease of the arterial system which is probably caused by a filterable virus with an affinity for the arteries and is characterized by necrosis of the media with fibrinous exudation. The chief secondary changes in the arteries are aneurysm formation, thrombosis, and hemorrhage. Death is usually due to hemorrhage from the rupture of an aneurysm or to necrosis or insufficiency of vital organs resulting from thrombosis of the arteries.

The disease is four times as frequent in males as in females. In about 50 per cent of the cases it occurs between the ages of twenty and forty years. Its duration varies from a few weeks to six months.

The symptoms are a septic type of temperature, polyneuritis, polymyositis, hematuria or nephritis, abdominal cramp-like pains, and progressive emaciation. The treatment is unknown. By some, roentgenotherapy is recommended. Causalgia is discussed elsewhere.

ERYTHROMELALGIA

Erythromelalgia, or red painful extremities, is a vasomotor disturbance which represents the paralytic type of peripheral vascular disease. It was first described by S. Weir Mitchell, in 1872.

According to Brown, the four fundamental criteria essential for the

diagnosis are (1) a bilateral symmetrical burning pain in the extremities, (2) a sharp increase in the heat of the affected parts with redness flushing, and congestion of varying degree, (3) the production and aggravation of the distress by heat and exercise, and (4) relief from rest, cold, and elevation If vasodilation is present, it parallels the degree of pain or distress, and is bilateral and intermittent, the diagnosis of erythromelalgia is warranted, provided primary or associated disease is absent In some cases the diagnosis may be rendered difficult by attacks of gout

According to Buerger, there is a deep-seated, poorly limited, and constant burning which is susceptible to exacerbations and quite different from the pain described in cases of neuralgia A similar sensation is noted in frozen extremities in which the circulation is rapidly restored by warmth This suggests that the pain is related to alteration in the vessels In erythromelalgia it is possible that the pain is due to direct irritation of the sensory sympathetic elements in the vessel walls It is relieved by ice-cold baths and contrast baths to the foot, and occasionally by elevation Epinephrine administered hypodermically may give temporary relief Foreign protein therapy has its advocates

OPERATIONS ON ARTERIES

Operations on the arteries are ligation and periarterial sympathectomy Lewis ties off the femoral artery just below the point where the profunda femoris is given off The principle of this operation is to force the blood through the collateral circulation and thereby open up new channels Periarterial sympathectomy was originally described by Jaboulay and popularized by Leriche

Arteriectomy —Leriche believes that as soon as an artery becomes obliterated, it should be resected After its resection the periphery of the affected member begins to warm up, the oscillometric index increases, the pulse may reappear, certain muscles reacquire their contractility, and the trophic disturbances disappear

Embolectomy —Over 200 embolectomies have been reported by Swedish surgeons alone Murray of Toronto advocates the injection of heparin immediately after embolectomy to prevent new thrombi from forming

ARTERIOVENOUS ANEURYSM

In an arteriovenous aneurysm the blood does not pass through the capillaries, but flows directly from the artery into the vein The condition may be congenital or acquired In the congenital type, the abnormal communications between arteries and veins are usually multiple and extremely difficult to treat Acquired arteriovenous aneurysms are usually due to bullet or puncture wounds The differ-

ence in the color of the blood from the two extremities is sufficient to establish the diagnosis because the venous blood from the affected extremity is bright red, indicating an admixture of arterial and venous blood, whereas that from the corresponding normal extremity is dark red. The area pulsates and a bruit can usually be heard.

Horton found that the temperature of the affected limb may be 4° C. higher than that of its mate. He lists the characteristics of congenital arteriovenous aneurysms of the extremities as: increased length and size of the extremity; increased elimination of heat; and a high admixture of arterial blood in the regional veins. The bradycardiac sign is confirmatory evidence, but is frequently absent if the fistulas are small. Pressure on the brachial or femoral arteries is followed by a drop of from 10 to 20 beats. Bruits are usually absent. The finding of arterial blood in the regional veins is diagnostic.

Horton reported 17 cases of congenital arteriovenous aneurysms of the extremities with osseous hypertrophy.

Hemihypertrophy of the Extremities Associated With Congenital Arteriovenous Aneurysm.—In a review of the literature, Lewis was able to find the reports of only 30 acceptable cases of the congenital form of arteriovenous communication. Horton saw 23 cases in a period of eighteen months. The observation that one limb is longer than the other is most suggestive. The excess of blood in the limb may stimulate overgrowth of bone.

Ulcers which develop in connection with arteriovenous aneurysms of the lower extremity occur below the arteriovenous opening. If a tight bandage is applied so that the vein is compressed at the point of the opening and blood is forced to pass through the capillaries, such ulcers will heal rapidly.

EMBOLISM

Embolism of arteries of the lower extremity is due to the same causes as embolism of any systemic artery. The clots usually come from the left auricle or from the wall of the left ventricle. The most frequent heart conditions associated with embolism are auricular fibrillation, mitral stenosis, congestive heart failure from any cause, coronary infarction and aortic aneurysm.

Emboli are generally arrested where the blood passes from an artery having a greater to one having a smaller lumen. It is almost impossible to distinguish between embolism and thrombosis in an extremity according to Sir Thomas Lewis.

(Symptoms of embolism of arteries of the leg and foot will be listed under the specific artery involved.)

Common Femoral Artery.—According to Lewis, the pain due to embolism of the common femoral artery may be confined to the foot, lower

leg or region of the knee The patient is unable to move the toes and sometimes the foot The foot and leg become numb, cold and discolored Gangrene of the toes, foot, or leg may follow

Popliteal Artery —Pain due to embolism of the popliteal artery is usually confined to the foot, and may occur in the lower leg However, pain may be entirely absent Movement of the toes, and often the ankle, may be lost The foot is cold, numb, and discolored Occasionally gangrene of the toes occurs

Smaller Arteries —Occlusion of the anterior or posterior tibial arteries may give rise to no signs or symptoms, other than a loss of the corresponding pulse

The oscillometer is of great help in determining the site of the embolus

The course of the lesion is extremely variable and depends upon the location In obstruction of the common femoral artery gangrene is frequent, and when it occurs, deaths usually follows In simple popliteal obstruction gangrene is less frequent, and there is usually a complete recovery of function When the smaller arteries of the leg and foot are occluded, recovery of all function is the rule It may be difficult to differentiate the pain produced by emboli from the intermittent claudication of Buerger's disease or arteriosclerosis

When emboli are infected, the course and symptoms depend on the severity and activity of the inflammatory process There is usually tenderness, swelling, local reddening of the skin, and in some cases local aneurysm and abscess

Treatment —Embolism of the arteries of the extremities is primarily a surgical problem However, Lewis states that because of the adequate collateral circulation of some vessels, operation is to be recommended only in those cases in which pain is severe and prolonged, or the signs of motor and sensory loss are extensive, profound, and permanent On the other hand, if operation is deemed advisable, it should be done within six hours The outlook for successful embolectomy rapidly decreases after twelve hours and is almost gone after forty-eight hours

Conservative measures can be attempted before the six-hour limit, but if unsuccessful within this period, should not be continued Sometimes it is possible to massage the clot onwards by manual manipulation over the artery

Embolectomy is usually done under local anesthesia The artery is exposed and the clot is removed through an incision in the wall of the artery, between clamps The clamps are next cautiously removed in sequence to observe the direction of the current and the patency of the vessel The artery is then sutured and the clamps removed

Postoperative massage and passive movement encourage recovery. The Pavaex machine is recommended in the postoperative care.

(The treatment of gangrene is discussed elsewhere.)

Factors in the production of vascular disturbances of the extremities include:

1. Footwear.
2. Wind producing frostbite.
3. Contact with metal.
4. Circulatory stagnation which is corrected by exercises of the legs.
5. Anoxemia such as is found in aviators, producing anemia, local tissue shock and hemorrhage.
6. Malnutrition (should be combated with Vitamin C.)
7. Trauma due to vigorous rubbing.
8. Infection.
9. Too rapid warming of tissues.

The relation of vascular injuries to foot and ankle lesions is both a medical and a surgical problem.

It is a foregone conclusion that if the foot and ankle do not have circulation, death is inevitable. The second question is: Does the circulatory apparatus bring proper nutrition to the parts? In all circulatory or neuro-circulatory disturbances it is important to emphasize frequent changes of position of feet and legs, even if only momentarily.

The policeman who stands a great deal is more apt to have trouble than the policeman who walks a great deal. The professional man sitting at his desk should elevate his feet for a minute or two as often as he can. He should make frequent trips around the office as often as he can in order to improve his circulatory status.

The reader who is interested in the subject of circulatory disturbances of the extremities during World War II is advised to read the writings of Wright and Abramson. For information on vascular lesions, read the writings of Elkin and Schumaker.

Sympathetic Nerves.—It is a fact that the sympathetic nerves have a very important bearing on the integrity of the peripheral vascular mechanism.

It is remarkable how great were the advances made during World War II on the relation of the sympathetic nerves to the peripheral vascular mechanism.

Not all these advances have been made by military personnel. There have been outstanding advances by civilian doctors working on the same problem. I have seem limbs that ordinarily would have been amputated that were saved by sympathetic nerve procedures such as sympathetic blocks that were repeated and by sympathetic resection.

The following outline was used by Dr Harris B Shumacker, Sr, Chief of Surgical Vascular Section at Mayo General Hospital during World War II

SPECIAL VASCULAR EXAMINATION*

NAME

CHIEF COMPLAINTS List in order of severity Indicate duration of each

RELEVANT FAMILY HISTORY

PAST HISTORY List complaints such as sweating, coldness, dryness of hands and feet, any trauma to the extremities, environmental or other conditions which aggravate or relieve symptoms List negative as well as positive findings Record whether hands and feet are normally warm or whether there is a tendency to coldness, whether sweating is normal or excessive

HABITS Number of cigarettes per day, amount of alcohol consumed

PRESENT ILLNESS Time and place of onset of present illness, description of conditions under which complaints were first experienced Record briefly, previous hospitalizations In case of gunshot wound record such data as whether bleeding was excessive, whether tourniquet was used, and whether transfusions were administered Record signs and symptoms noted by the patient and whether they have progressed or improved with a note as to efficacy of any previous treatment This should include inquiry regarding pain, claudication, rest pain, tingling and burning, also, numbness, motor weakness and other neurological complaints Also, color changes, cyanosis, pallor, rubor Changes in temperature and in sweating Trophic changes such as vesicles, ulcers, desquamation of skin, gangrene, nail loss, or slow growth of nails, infection, fungus or pyogenic, and stiffness

PHYSICAL EXAMINATION Routine

COLOR CHANGES Record color of limb in dependency, elevation, and in horizontal position The degree is recorded as grade 1 to 4, 4 being very severe

BLOOD-VESSELS Record whether peripheral arteries are tortuous or thickened' whether there are abnormal pulsations, bruit or thrill If the latter are present, describe location and extent over which present, whether they can be obliterated by pressure, and if so, where List pulsations as to 0 to 4 (0 absent, 4 normal Ordinarily, record pulsations in brachial, radial, ulnar, femoral, popliteal, dorsal, pedal and posterior tibial arteries, and others where indicated Describe any venous dilation, varicosities, thrombosis, etc Record venous filling time of veins of hands or feet

OTHER FINDINGS Sweating, edema, scleroderma, epidermophytosis, trophic changes, such as involvement of nails, hair, thickening or atrophy of skin, ulcers, gangrene, amputations Record neurological changes, sensory and motor If edema or swelling is present, record measurements at measured and specific levels

SPECIAL TESTS Skin temperature Oscillometry Any abnormality of walking Homan's sign in thrombophlebitis Claudication time, if indicated Other tests where indicated In any patient with aneurysm determine time in seconds for color return after blanching digits in the involved and contralateral extremity, with and without obliteration of the aneurysm by digital pressure Record the time required for the veins of the involved hand or foot to fill when the limb is lowered to the horizontal

* Courtesy of Yale University Surgery Dept

position after the extremity has been elevated and a tourniquet placed distal to the aneurysm at 60 mm., and the aneurysm obliterated by pressure. The time is recorded in seconds, beginning with return of the limb to horizontal position and ending when the veins are visibly filled. Record the time required for reactive hyperemia to occur in the involved hand or foot after five minutes of total arterial occlusion with a blood-pressure cuff and with aneurysm obliterated. The limb is elevated and a cuff placed distal to the lesion and inflated to about 200. After four minutes the aneurysm is occluded and this occlusion is maintained until the test is over. The cuff is deflated quickly at the end of five minutes and the time recorded in seconds when the flush begins and when it is complete in the digits. Record, if possible, the blood-pressure distal to the lesion in the involved wrist or ankle and in the contralateral limb. With A–V fistulas this ordinarily must be done by digital palpation of arteries in foot or hand. In A–V fistula record pulse and blood pressure changes with obliteration. Obtain photographs of lesions which are visible. Obtain roentgen-rays of heart for size in all cases of A–V fistula. Patient's height and normal weight must be given on request slip. Also obtain EKG on all A–V fistulas Repeat heart roentgen-rays post-operatively, and EKG.

IMPRESSION:

CONTROL OF SYMPATHETIC IMBALANCE IN POST-TRAUMATIC AND OTHER VASCULAR DISEASES*

Wars have advanced our knowledge of vascular diseases. Among the milestones may be mentioned: injury to and ligation of, arteries, traumatic aneurysms and causalgia. In World War I, Leriche first showed the value of sympathetic surgery (periarterial sympathectomy) in the management of certain painful lesions of the extremity. Since then, many advances have been made in our knowledge of vascular diseases and the disturbance of vascular physiology associated with trauma.

The term sympathetic imbalance is used by Mahorner since the vascular disturbance in post-traumatic painful lesions such as causalgia and Sudeck's atrophy, while frequently vasospasm, is sometimes vasodilation. Following trauma of various types from mild contusions to sprains, including soft tissue and bone injury, the period of recovery is not infrequently complicated by a vascular disturbance. In exaggerated or more prolonged form, post-traumatic pain and edema become abnormal. Not infrequently these complaints may be differentiated from traumatic neurosis and malingering only with difficulty. Post-traumatic pain with or without edema is usually associated with a vascular disturbance and a sympathetic imbalance. Relief of pain is occasioned by disconnecting the sympathetic temporarily or permanently by novocain blocks of the sympathetic ganglia or by ganglionectomy. Mahorner believes like Leriche, that deep

* Reprint from Mahorner, Howard "The Mississippi Doctor," January 194[illegible], pages 352–355.

burning and aching pain in certain post-traumatic conditions is carried over the sympathetic fibers

Causalgia —Causalgia is a more severe type of the same affection Weir Mitchell described it in soldiers who during our Civil War had injuries near nerves In his cases the patients complained of an intense burning and aching pain in the distribution of the nerves Trigger zones and extreme hyperesthesia were noted by him He had little to offer in the way of treatment Leriche found the same existing in soldiers injured in World War I The first patient upon whom he performed a periarterial sympathectomy for similar complaint was a soldier This resulted in a cure

Sudeck's Atrophy —A third stage of the post-traumatic syndrome is Sudeck's atrophy In this phase subjective pain and tenderness are out of all proportion to the objective findings In addition, osteoporosis of bones in the involved area is diffuse and more or less uniform This may be noticeable in roentgenograms of bones of the foot Atrophy of muscles is moderate to severe In Mahorner's experience, temperature studies done with thermocouple in patients with pain and atrophy usually show the involved extremity had lower skin temperatures than the opposite extremity This is contrary to the extensive and detailed studies made by Miller and DeTakats

The question is, are all of these syndromes one and the same disturbance in vascular and sympathetic physiology following trauma, or are they separate clinical entities entirely distinct from each other? There is much evidence that they are all various stages of the same process or various degrees of severity of the same lesion

Vascular Diseases —Among the vascular diseases in which there is an absolute or relative imbalance of the sympathetic nervous system may be mentioned those in which an injury to, or clot in, a vessel causes a reflex vasospasm in that extremity and even in the opposite extremity, such for example as seen in thrombophlebitis When thrombosis occurs in a vein, this vein undergoes a certain amount of vasoconstriction and in addition to this, other vessels in that extremity including large and small arteries, become vasospastic to an abnormal degree The vicious circle of vascular spasm causes more ischemia which in turn creates more capillary permeability and edema and more obstruction To a certain extent this same disturbed physiologic process occurs in thrombo angiitis obliterans where clots in arteries set up a reflex vasospasm in addition to the organic obstruction produced Even should vasospasm not exist in thrombo-angiitis obliterans, there is a certain normal tone in the vessels and the small arterioles and capillaries which if released, would permit a more extensive collateral circulation around the obstruction in the large arteries

Innumerable measures have been advocated for the control or

alteration of abnormal or normal sympathetic vasoconstriction. Among the general measures most commonly used and most obvious are postural changes, elevation for edema and cardiac level or slight dependency for ischemia. Other general measures are rest, and on the other hand, functional use; walking with supportive bandages or elastic stockings; or in such instances as Sudeck's atrophy, walking in a cast with a walking iron. Böhler has contributed one of the best preventive measures for causalgia and Sudeck's atrophy in his teaching of immobilization of the extremity with use of it. The question of cold and heat is still debatable. Heat to the very ischemic extremity is contraindicated, because it causes a demand for increased metabolism in a cell that had decreased oxygen and metabolic supplies.

Drugs have been particularly disappointing in their sustained effect on the sympathetic nervous system. Prostigmine, pancreatic extracts and mecholyl to cause sustained vasodilation, have met with indifferent success in the hands of most authors. Mechanical devices such as pavaex, the rhythmic constrictor cuff, and oscillating bed have helped only slightly. The best of these is the pavaex, in Mahorner's experience, and that only excellent when the patient is economically able to have his own and use it for short times daily over a long period. The alternate constricting cuff has some theoretical objection in that it traumatizes the already involved artery. The oscillating bed is entirely inadequate and unhelpful.

A local operation such as novocain infiltration or excision of trigger scars is sometimes surprisingly beneficial. The same may be said concerning the excision of thrombosed segments of arteries. Judging from the reports from such reliable sources as Leriche and Homans, the attack on the initiating point of reflex vasospasm by excising a thrombosed segment of artery results in marked improvement in the circulation. Obviously, such an operation has a limited field and must be directed to instances in which a small segment of a larger artery to an extremity has been occluded.

A method of indirect attack on vasospasm is repeated sympathetic blocks with novocain. This is often of great value. After properly placing the needle, 5 cc. of novocain (1 per cent) are infiltrated near the first, second, third and fourth lumbar ganglia. In the presence of causalgia, a few minutes after the block is completed, the pain abates or ceases and the extremity becomes warm; stiff joints become less painful and greater range of motion may be forced with little discomfort. After a period of three to twelve hours the pain and vasoconstriction might return, but blocks on consecutive days or on alternate days or even at intervals of twice a week over a period of a week or ten days may turn the tide in favor of good blood supply and rapid return of joint function in an otherwise vascillating or obstinate condition

Mahorner has used sympathetic blocks repeatedly in patients who have causalgia or who have a stiffness and pain following injuries and fractures and in whom the question of mobilization was proceeding slowly, and have found such therapy surprisingly gratifying in that recovery is hastened

Ganglionectomy is justified in certain vasospastic arterial states with or without organic disease when the patient is young, much more often than when he is elderly There is no definite method of precision in determining that a ganglionectomy would have a result that would justify the undertaking But it is certainly justified where the question of impending gangrene or chronic ischemia so incapacitates an individual that sympathetic release even of normal vascular tone would likely carry him over a period of improvement until further vascular adjustment by organization and opening of the collaterals turns the tide in favor of recovery

Ganglionectomy for causalgia or Sudek's atrophy is indicated in severe types of these lesions, but usually these conditions may be improved or obviated without radical surgery, by repeated novocain blocks of the sympathetic ganglia, associated physical therapy and forced use of the extremity involved In the severer type ganglionectomy is indicated The results in such lesions are truly remarkable

CONTROL OF PAIN IN POST-TRAUMATIC AND OTHER VASCULAR DISTURBANCES

Mahorner divides the pains of the sympathetic nerve system into 5 clinical groups (1) Post-traumatic pain (2) Causalgia (3) Sudeck's atrophy (4) Sympathalgia (5) Non-traumatic reflex vasospasm (from inflammation, thrombosis and embolus)

Under this classification, post-traumatic pain is a condition in which the objective findings are minimal with sub-clinical vasospasm and possibly edema Causalgia portends pain with more objective findings, edema, paresis of a nerve, and sometimes pain only in the distribution of a nerve In Sudeck's atrophy, pain is associated with osteoporosis Sympathalgia is sympathetic nerve pain not necessarily associated with traumatic onset Another group of painful conditions associated with vasospasm but not caused by external trauma are those of inflammation, embolus and thrombosis

The operative approach for preganglionic section of the thoracocervical sympathetic nerves (third and second thoracic and stellate ganglia) may be from behind (Smithwick) or from the front

Buerger's disease is one of the most terrible afflictions which may beset a young man It disables by pain, a fact which is too infrequently appreciated A patient with Buerger's disease may be able to walk

six blocks and then have to stop because of the pain (intermittent claudication). Even with considerable vascular reserve, the dorsalis pedis and posterior tibial arteries are pulseless. The claudication, however, is not what impresses the patient so much. It is the rest pain, the boring, aching, intense pain in the ball of the foot, in a toe, or in the instep which annoys him and keeps him awake at night and which disables him so much. He could work at many jobs with a claudication which stops him only after three or six blocks, but he can work at none with the rest pain which nightly keeps him awake.

Gangrene or impending gangrene is a late stage of Buerger's disease. Usually the patient has had the disease a year or two before this complication supervenes. In the earlier stages it is easier to accomplish much more for the patient.

Sixty patients with conditions requiring *temporary or permanent* interruption of the sympathetic nerves are reported by Mahorner. Twenty-two operations for permanent section of the sympathetic nerves have been performed in this group.

Pains influenced by interruption of sympathetic nerve function are varied. They occur in vascular disease with associated vasospasm and may be attributable not only to ischemia, but also directly to the vascular spasm. Vascular changes occur and persist after trauma; and pain associated with these may prolong disability unduly. These pains may be surprisingly relieved by paravertebral sympathetic nerve blocks permitting more active physical therapy for mobilization of joints. Such repeated nerve blocks may often shorten a convalescence dramatically.

Sympathectomy is indicated in all patients with thrombo-angiitis obliterans under fifty years of age. The operation gives many times more increase in vascular reserve in patients with early Buerger's disease than in those affected with a late stage.

Raynaud's disease is not a fault of the sympathetic nervous system. Sympathectomy for it is frequently disappointing.

The pain in post-traumatic vascular diseases resembles that of other vascular disturbances such as Raynaud's disease and the "rest pains" of thrombo-angiitis obliterans. The conditions included are not the immediate consequences of trauma, they are found in that period of convalescence when the immediate reaction to trauma has passed and healing of bone and soft tissue has occurred. The pain is a constant symptom, it may disable, but sometimes the objective evidence to support its reality is so obscure that the possibility of malingering may rightfully be [illegible]rtained.

Following n[illegible] Mahorner fou[illegible] [illegible]emity became warm, and the pain [illegible] temporarily [illegible] [illegible]ich were so painfully

stiff that they could not be moved before the block, could be forcefully moved after the block, with very little pain The next day the pain returned but with less and less intensity after each succeeding block Nerve blocks were performed every other day or every third day for three to six times The disabling pains finally failed entirely to reappear Joints which had been stiff for several months and which resisted mobilization because of pain, were returned to normal function in a relatively short time

To be effective the nerve block with novocain usually has to be performed repeatedly In some instance permanent section of the sympathetic chain is indicated The performance of paravertebral sympathetic nerve blocks in the thoracocervical or the lumbar region is not technically difficult, and with reasonable precaution and skill it is not at all dangerous

VASCULAR INJURIES DUE TO COLD WITH PARTICULAR REFERENCE TO THE LATE PHASE OF TRENCH FOOT

In the extreme cold of the stratosphere, the tissues of a hand which becomes exposed through loss of a glove may be frozen solid almost instantaneously

The evidence presented shows that the blood-vessels in cases of late trench foot for the most part are not originally involved Nothing conclusive however can be said about functional changes which most certainly have to do with skin temperature, cyanosis and flushing It is believed, based only on clinical impression, that the small blood-vessels are in a sensitized state, responding abnormally in a qualitative and quantitative sense to their usual stimula This belief is strengthened by the appearance of a typical Raynaud syndrome in a few cases in which trench foot had developed approximately one year before The appearance of such syndromes in men more than thirty years of age and in whom such phenomena had not been present previously leads to speculation as to the likelihood that in additional cases of this disorder such symptoms may develop in the next few years

For the most part, the perpetuation of symptoms in late cold injuries depends on the slow resolution of a chronic sterile inflammatory process with fibrosis within the tissues rather than on organic changes in the blood-vessels themselves These changes have been demonstrated in the subcutaneous tissues, in the tendons, periarticular structures, in muscle, about the sweat glands, and in perineural structures There is little wonder that the extremity in cases of late trench foot tends to be stiff, painful on weight-bearing and swollen after exercise, even when its clinical appearance is quite normal

ALCOHOL INJECTION OF LUMBAR SYMPATHETIC NERVE TRUNK

The advantages of interrupting the sympathetic nerve supply to an extremity in which there is a circulatory deficiency due to vasospastic disease such as thrombo-angiitis obliterans or Raynaud's disease has been generally accepted, as a result of the pioneer work of Leriche and the subsequent investigations of many physicians.

Lilly considers paravertebral alcohol injection of the lumbar sympathetic ganglions a relatively safe procedure when carefully done. Many inoperable cases where the person is suffering from arterial insufficiency of the lower extremities can be relieved by this relatively simple procedure. It is not advocated as a substitute for surgical sympathectomy but as a second choice when surgery is contraindicated.

Allen finds that interruption of the sympathetic pathways to the extremities has a definite place in the treatment of certain peripheral lesions, particularly those that have to do with vasospasm. In the arteriosclerotic group particularly, and in a great many cases of thrombo-angiitis obliterans this procedure does have definite merit.

Extensive experience has created remarkable advances in peripheral vascular surgery.

Dr. Matas, generally recognized as the father of peripheral vascular surgery in America, stated that the men at a certain military vascular center had seen more of this type of surgery in six months than he had in sixty years.

VASCULAR INJURIES OF WARFARE

The arrest of hemorrhage and the preservation of an adequate arterial supply to the extremities according to Elkin is one of the main concerns of military surgeons.

The number of such injuries has increased steadily due to the introduction of higher velocity projectiles of smaller caliber. In addition to the ordinary wounds caused by machine gun, rifle bullets and shrapnel, a great many multiple injuries are produced by the fragmentation of land mines, grenades, and aerial bombs. These latter may produce as many as one hundred small individual wounds scattered throughout the body without causing death, thus increasing the incidence of trauma to blood-vessels. The sequelae of these injuries is encountered with increasing frequency. Moreover improved methods in the control of hemorrage, shock, and infection have preserved more individuals for subsequent observation and study.

Elkin reported on his experience at Ashford General Hospital which was one of the three military centers for vascular surgery. He divided vascular injuries as a result of war wounds as follows:

1. Those in which the blood-vessel is completely severed in which

vasospasm exists to such an extent as to so impoverish the blood supply that death of the part or useless fibrosis, results

2 Activation of previously existing blood-vessel disorders or tumors, such as congenital nevi and preexisting vascular injuries

3 *Partial severance of a vessel producing a false aneurysm or arteriovenous fistula*

The three main types of arterial injury are

1 Arterial occlusion from severance or vasospasm

2 Blood-vessel tumors and injuries activated by trauma

3 Aneurysms and arteriovenous fistulæ

Blakemore and Lord devised a non-suture method of bridging gaps in main arterial defects, which in a large series of animal experimentations *has proven remarkably effective and has been used in a sufficiently* large number of clinical cases to show that it is not only feasible but readily carried out

INTERMITTENT CLAUDICATION AS A RESULT OF ARTERIAL SPASM INDUCED BY WALKING

Leary and Allen observed four patients who exhibited the syndrome of *intermittent claudication as a result of arterial spasm alone* With two exceptions the existence of such a syndrome has been ignored almost entirely in textbooks on vascular diseases and other medical writings In 1922, Thomas, a Frenchman, wrote that a brief period of arterial spasm after muscular exercise was noted in some cases in which the circulation was otherwise normal and that this spasm was followed immediately by vascular dilation Pearl, in 1937, reported 6 cases *in which there were symptoms of arterial insufficiency caused by arterial spasm In his cases the onset of pain was definitely* associated with acute ischemia of the feet and diminution or disappearance of pulsations in the arteries In all of the cases reported by Pearl, normal or nearly normal vasodilation occurred as a result of anesthetization of peripheral nerves There have been case reports of intermitten claudication, with a normal vasodilation response and normal pulsations *in the peripheral arteries*, but the authors fail to state whether or not pulsations *in the arteries disappeared as a result of* walking

Veal has shown by arteriographic studies that intermittent claudication may affect patients whose large arteries are patent throughout their course and have normal lumens He felt that the defect in the circulation which causes intermittent claudication was in the small arterial branches, which were few in number, irregularly distributed, and considerably *shorter than normal* We have ordinarily considered this the explanation for the intermittent claudication which affects

patients whose circulation seemed normal during rest. The syndrome of intermittent claudication as a result of arterial spasm induced by exercise is unusual, for almost invariably, exercise causes arterial dilation instead of spasm.

THE DIAGNOSIS AND MANAGEMENT OF CHRONIC OBLITERATIVE VASCULAR DISEASE

A review* of the records of 112 patients with thrombo-angiitis obliterans and 176 patients with arteriosclerotic gangrene under the care of the Peripheral Vascular Clinic at the Massachusetts General Hospital, and 565 patients with diabetic gangrene under McKittrick's care at the New England Deaconess Hospital suggests that:

1. Thrombo-angiitis obliterans is a disease of young and middle-aged men with symptoms of years' duration.
2. It is rarely seen in a woman.
3. Calcium deposits in arteries are only rarely demonstrated by roengten-ray examination and when present are slight in amount.
4. Certain cases in men between the ages of forty and fifty-five may be indistinguishable clinically from cases of gangrene due to arteriosclerosis.
5. In spite of improvements in management of these cases 30 per cent of the cases have come to major amputation.
6. Twenty per cent of 66 proved cases of arteriosclerotic gangrene came to amputation through or above the lower part of the leg.
7. Early and adequate treatment of diabetic gangrene is of great importance.

ARTERIOSCLEROTIC GANGRENE

Arteriosclerotic gangrene with or without the complication of diabetes carries a heavy operative mortality. In Taylor's series when major amputations were done the case mortality was 37.6 per cent and the amputation mortality 32 per cent. He called attention to the relation of operative procedure and stump healing to mortality.

The usual anatomic fascial plane closure in the majority of instances (*a*) devitalizes the already poorly nourished stump tissues, thus predisposing to necrosis and suppuration, (*b*) allows inadequate drainage for infected stumps or stumps which become infected, (*c*) results in only a small number of promptly healing stumps (21.3 per cent of those operated on in the present series), (*d*) definitely increases the operative risk and (*e*) does not shorten the average postoperative hospital stay.

Of all the measures that have been proposed in the treatment of

* New England Jour. Med.

peripheral vascular disturbances it appears that the ones that have stood the test of time best are

1 Sympathetic nerve operations
2 Buerger-Allen exercises
3 Oscillating bed
4 Correction of metabolic disturbances
5 Correction of obesity
6 Elastic hosiery

Typhoid vaccine to produce fever therapy is very efficacious in some cases

Changes from erythema to gangrene can occur in diabetes, syringomyelia and other diseases of the spinal cord Ulcers of the feet may occur in sickle cell anemia

If the cause of an inflammatory condition of the feet is not specifically determined, *Madden advises a general physical and laboratory examination*

The foot with deficient arterial circulation is much more vulnerable to slight trauma or infection than the normal foot, so that apparently minor conditions may be extremely serious

Minor blisters, abrasions, ingrowing nails, corns, calluses, fungous infections and other simple disorders may be the source of intractable infection or even gangrene

The drying of feet, shoes and socks is very important In the cases of sock dampness, cold and constriction are very harmful Ventilated shoes are of some definite value

Rapid strides have characterized the developments in the treatments of peripheral vascular disease during the past decade The recognition of the associated fundamental physiologic derangement has permitted an approach toward accuracy in prognosis and efficacy in therapeusis Ochsner and DeBakey's table appears on page 622

It has been affirmed repeatedly that peripheral vasoconstriction can be initiated by reflex activity of the autonomic nervous system and by an increased secretion of epinephrine Cold and emotional excitement produce vascular spasm by reflex excitation of vasoconstrictor impulses to blood-vessels and by reflexly increasing the secretion of epinephrine Thus the mechanism of peripheral vasoconstriction under such circumstances may be humoral as well as neurogenic The surgical procedure indicated represents an attempt to diminish the neurogenic activity However, the part played by the humoral factor in vasospastic functional and vasospastic organic conditions may be important In an attempt to decrease also the reflex activity of this humoral factor, Leriche, Pereira and DeBakey advocated simultaneous resection of the splanchnic nerves and the first

Procedures for Studying Vasospasm

- I. Interruption of sympathetic impulses by analgesia or anesthesia
  - A. *Localized (procaine hydrochloride)*
    - 1. Peripheral nerves
    - 2. Spinal cord
    - 3. Sympathetic ganglions
  - B. General anesthesia
    - 1. Inhalation
      - (*a*) Ether
      - (*b*) Nitrous oxide
    - 2. Intravenous
    - 3. Rectal
- II. Inhibition of sympathetic tone
  - A. Physical (heat)
    - 1. Indirect: Injection of foreign protein
    - 2. Direct application
      - (*a*) Generalized: Increased environmental temperature
      - (*b*) Localized
        - (1) Involved area
        - (2) Uninvolved area
  - B. Physiologic: Reactive hyperemia
  - C. *Pharmacologic*
    - 1. Alcohol
    - 2. Nitrites

Methods for Determining Effect of Vasospasm on the Peripheral Blood Supply

- I. Calorimetric
  - A. Thermocouple
  - B. Mercury thermometer
- II. Oscillometric
  - A. Pachon's method
  - B. Recording
- III. Plethysmographic
  - A. Arterial
  - B. Arteriolar
- IV. Vascular visualization
  - A. Direct: Microscopic examination of capillaries
  - B. *Indirect: Arteriograms*

Clinical Factors Indicating and Influencing Spasticity

- A. Indicative factors
  - 1. Age
  - 2. Sex
  - 3. Color changes
  - 4. Pulsation
  - 5. Hyperhidrosis
- B. Influential factors
  - 1. Emotion
  - 2. Environment
  - 3. Tobacco

and second lumbar sympathetic ganglions In cases of vasospastic functional and vasospastic organic peripheral vascular disease of the lower extremities in which lumbar sympathectomy is indicated, the additional performance of splanchnic section can be readily accomplished with little or no technical difficulty through a new extraperitoneal approach which they describe

When one reads of the results of various methods of treatment for chronic occlusive arterial diseases, two things were impressive Allen reported results that are surprisingly good The reported results of one particular method of treatment duplicate surprisingly the reported results of other methods of treatment This correlation can be explained in several ways Perhaps the results are as good as reported because of specific methods of treatment and perhaps the surprising correlation of good results of individual methods of treatment is due to the fact that only a certain percentage of patients can be benefited Perhaps also there is too much enthusiasm on the part of the investigator who reports good results either because he has a definite pride in the method which he has originated or because he is not sufficiently experienced to exercise cautious judgment This would appear to be definitely true when other students cannot confirm the good results of a specific method of treatment Perhaps the specific method of treatment is not responsible at all for improvement or, if it is, it is responsible only remotely while most benefit originates from good general care such as cessation of smoking, rest in bed, warmth, and comfort

The number of reported cures for chronic occlusive arterial diseases indicates that the field of vascular diseases has come of age Almost all the good reports of treatment of thrombo-angiitis obliterans are based on clinical results There is little objective evidence to support the conclusion that much of the treatment causes a definite increase in the flow of blood to extremities deprived of blood Even if an individual treatment causes increased circulation transiently, one cannot conclude that repeated treatments cause a permanent increase in circulation unless there is definite objective evidence that this is true Horton has shown that many patients receive little or no treatment and that, of these, about 60 per cent will require amputation within ten years' time

Allen discusses two common peripheral arterial conditions, thrombo-angiitis obliterans or Buerger's disease, and arteriosclerosis obliterans

These two conditions have common symptoms, which are chiefly those of impaired arterial circulation to the peripheral parts Impaired arterial circulation produces coldness of the skin but many people who have cold skin have normal arterial circulation

Pain is a very important manifestation of impaired arterial circulation, and the most characteristic pain is intermittent claudication

Procedures for Studying Vasospasm

I. Interruption of sympathetic impulses by analgesia or anesthesia
- A. Localized (procaine hydrochloride)
  1. Peripheral nerves
  2. Spinal cord
  3. Sympathetic ganglions
- B. General anesthesia
  1. Inhalation
     - (*a*) Ether
     - (*b*) Nitrous oxide
  2. Intravenous
  3. Rectal

II. Inhibition of sympathetic tone
- A. Physical (heat)
  1. Indirect: Injection of foreign protein
  2. Direct application
     - (*a*) Generalized: Increased environmental temperature
     - (*b*) Localized
       - (1) Involved area
       - (2) Uninvolved area
- B. Physiologic: Reactive hyperemia
- C. Pharmacologic
  1. Alcohol
  2. Nitrites

Methods for Determining Effect of Vasospasm on the Peripheral Blood Supply

I. Calorimetric
- A. Thermocouple
- B. Mercury thermometer

II. Oscillometric
- A. Pachon's method
- B. Recording

III. Plethysmographic
- A. Arterial
- B. Arteriolar

IV. Vascular visualization
- A. Direct: Microscopic examination of capillaries
- B. Indirect: Arteriograms

Clinical Factors Indicating and Influencing Spasticity

A. Indicative factors
1. Age
2. Sex
3. Color changes
4. Pulsation
5. Hyperhidrosis

B. Influential factors
1. Emotion
2. Environment
3. Tobacco

and second lumbar sympathetic ganglions In cases of vasospastic functional and vasospastic organic peripheral vascular disease of the lower extremities in which lumbar sympathectomy is indicated, the additional performance of splanchnic section can be readily accomplished with little or no technical difficulty through a new extraperitoneal approach which they describe

When one reads of the results of various methods of treatment for chronic occlusive arterial diseases, two things were impressive Allen reported results that are surprisingly good The reported results of one particular method of treatment duplicate surprisingly the reported results of other methods of treatment This correlation can be explained in several ways Perhaps the results are as good as reported because of specific methods of treatment and perhaps the surprising correlation of good results of individual methods of treatment is due to the fact that only a certain percentage of patients can be benefited Perhaps also there is too much enthusiasm on the part of the investigator who reports good results either because he has a definite pride in the method which he has originated or because he is not sufficiently experienced to exercise cautious judgment This would appear to be definitely true when other students cannot confirm the good results of a specific method of treatment Perhaps the specific method of treatment is not responsible at all for improvement or, if it is, it is responsible only remotely while most benefit originates from good general care such as cessation of smoking, rest in bed, warmth, and comfort

The number of reported cures for chronic occlusive arterial diseases indicates that the field of vascular diseases has come of age Almost all the good reports of treatment of thrombo-angiitis obliterans are based on clinical results There is little objective evidence to support the conclusion that much of the treatment causes a definite increase in the flow of blood to extremities deprived of blood Even if an individual treatment causes increased circulation transiently, one cannot conclude that repeated treatments cause a permanent increase in circulation unless there is definite objective evidence that this is true Horton has shown that many patients receive little or no treatment and that, of these, about 60 per cent will require amputation within ten years' time

Allen discusses two common peripheral arterial conditions, thrombo-angiitis obliterans or Buerger's disease, and arteriosclerosis obliterans

These two conditions have common symptoms, which are chiefly those of impaired arterial circulation to the peripheral parts Impaired arterial circulation produces coldness of the skin but many people who have cold skin have normal arterial circulation

Pain is a very important manifestation of impaired arterial circulation, and the most characteristic pain is intermittent claudication

It is pathognomonic of impaired arterial circulation. Intermittent claudication occurs only in conditions characterized by impaired arterial circulation. It is a symptom which is brought on by exercise and relieved promptly by bed rest. It does not have any relation to cramps, which occur during the night while patients are at rest in bed, nor to the static distress of flat-feet or metatarsalgia. Intermittent claudication is characteristically a pain which is brought on by walking. It affects the calves of the legs and disappears promptly on cessation of the activity that produces it. The patients do not need to sit; they do not need to wait long for relief, which occurs promptly. Intermittent claudication may occur in regions other than the calves of the leg, although the calves are the most commonly affected. It may affect the arch of the foot, the digits, the wrist, the palm of the hand, the arm, the forearm, and occasionally it may involve the thigh and as high as the waist in high occlusion of the aorta.

The pain which occurs with rest is of three types generally. The first is a type of pain which occurs without any evidence of impaired nutrition of the skin, without any breaks in the skin, without any ulceration and without any gangrene. It is essentially the same type of pain which occurs in the presence of gangrene, for it is a manifestation of dying tissue. In the same connection there is a pain which is a manifestation of ischemic neuritis, a very definite clinical syndrome. This pain affects chiefly the feet and occurs in paroxysms, chiefly nocturnal in origin, which are usually very severe and at times are extremely difficult to control.

Then there is, of course, the pain associated with gangrene, which is well localized to the gangrenous region. One word of caution is necessary about the pain which occurs before the appearance of gangrene. Because this pain is associated with redness, it is commonly mistaken for pain due to inflammation. Hence, incisions are commonly made into the painful digits, chiefly the toes, or the toenails are removed, with the result that gangrene invariably occurs because of poor circulation. The one clue to the fact that this is not a pain due to some deep-seated infection is the fact that the digit is cold rather than warm, as one ordinarily would expect when there is inflammation.

Two other findings are important in the presence of impaired arterial circulation. One of these is the delay in return of color which occurs when the extremities are moved from the elevated to the dependent position. Ordinarily normal color returns about ten or fifteen seconds after the feet or the hands are moved from the elevated to the dependent position.

The most important thing in the treatment of thrombo-angiitis obliterans and arteriosclerosis obliterans is a feeling of optimism. Clinical experience shows that much can be done to rehabilitate these

patients, to preserve their extremities and to allow them to carry on with fairly normal activity. The relief of pain is always a great problem and the use of acetylsalicylic acid and codeine is usually a reasonably good method of control of pain but sometimes morphine is necessary. One should guard against habituation. Cobra venom, in Allen's experience has not been of any great value in the relief of pain in chronic occlusive arterial diseases. Occasionally the peripheral nerves may be sectioned and resutured, or alcohol may be injected into them to produce anesthesia of the peripheral parts, and sometimes this gives startling relief of pain without impairing motor function.

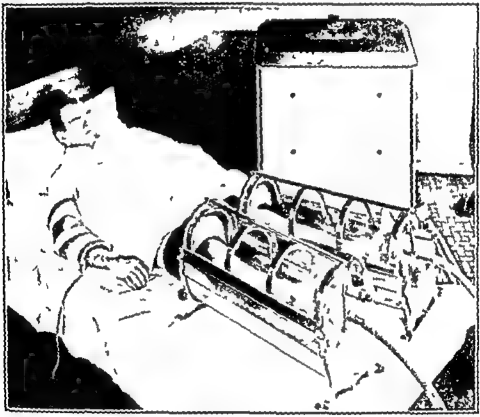


FIG. 325.—Suction-Pressure Therapy Unit as applied in peripheral vascular conditions of the lower extremities. The Burdick S-P Unit has sufficient capacity to treat two legs simultaneously, either in the same patient or in different patients. (Courtesy of the Burdick Corporation.)

Hines and Barker made a clinical study of 380 consecutive cases of arteriosclerosis obliterans. The clinical data have been supplemented by detailed gross and histologic studies of the arteries obtained from 32 legs that were amputated because patients had arteriosclerosis obliterans. The disease was found to occur predominantly among men between the ages of fifty and seventy years. There was no significant difference in racial incidence. The possible rôle of certain metabolic and chemical disturbances as etiologic factors has been empha-

sized. The lesions found in the arteries which were examined for pathologic changes consisted essentially of three components: (1) atheromatous plaques in the subintimal tissue, (2) degenerative changes in the medial coat, and (3) thrombosis. No significant difference was noted in the lesions of arteriosclerosis obliterans among diabetic and non-diabetic patients.

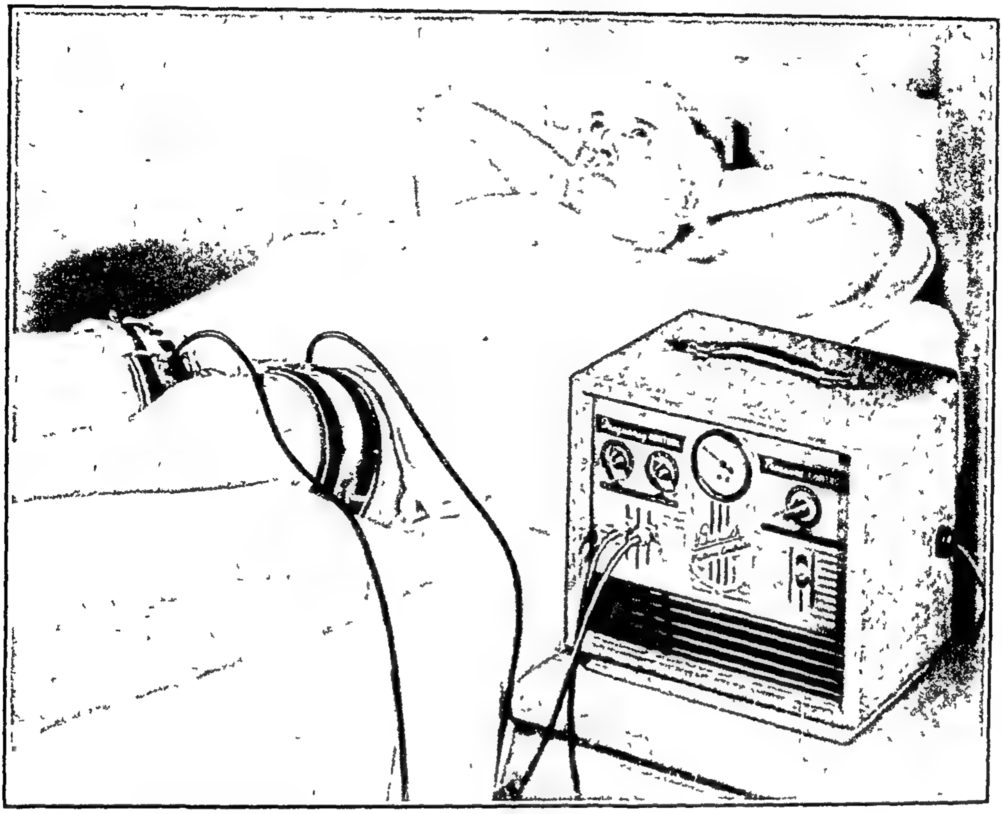


FIG. 326.—Light, portable rhythmic constrictor. (Courtesy of Burdick Corporation.)

MAJOR AMPUTATIONS FOR ADVANCED PERIPHERAL ARTERIAL OBLITERATIVE DISEASE

The salient differences between arteriosclerosis and Buerger's disease are described by Faxon as:

1. The incidence of Buerger's disease is less than one-third of that for arteriosclerosis with and without diabetes.
2. Buerger's disease is confined to males and involves younger patients than does arteriosclerosis.
3. The duration of symptoms prior to admission to the hospital is longer in Buerger's disease than in arteriosclerosis.
4. The five year life expectancy following successful major amputation is four times greater for patients with Buerger's disease than for those with arteriosclerosis.

5 An open lesion associated with Buerger's disease is invariably extremely painful, whereas pain is a far less striking factor in similar lesions with an arteriosclerotic basis, especially if associated with diabetes mellitus

Taxon outlines the following recommendations

1 A guillotine amputation through the lower part of the leg for critically ill patients with ascending infection is indicated as a life-saving measure

2 The open operation does not result in a satisfactory stump in cases of obliterative arterial disease and should be considered as a preliminary step to a secondary closed amputation at or above the knee

3 A closed amputation through the lower part of the leg rarely proves permanently satisfactory in cases of advanced arterial obliterative disease

4 The Gritti-Stokes amputation is the most satisfactory procedure for a patient with arterial disease whose general condition does not preclude the use of a prosthesis

5 A simple thigh operation is the safest major amputation of an extremity that can be carried out and is the procedure of choice for enfeebled patients for whom a major amputation is indicated

6 Drains should never be used in primary closed amputations

7 The decision as to the advisability and site of amputation should include due consideration of the nature of the underlying pathologic process, the future usefulness and life expectancy of the patient and the status of the peripheral circulation

In diabetic gangrene there are several important factors

1 The circulatory status

2 The metabolic status

3 The degree of trauma

In gas gangrene, which was not so common even in war, the circulatory status was more important than the severity of the trauma

RAYNAUD'S SYNDROME

Raynaud's syndrome is a vasospastic disorder without vascular occlusion characterized by vasomotor phenomena of the extremities superficial dry gangrene and trophic disturbances, with most characteristic findings in the capillary bed Over 95 per cent of the patients are women, mostly in the age group of seventeen to thirty-five

The vasomotor signs are the essential feature of the syndrome Rather suddenly precipitated by cold or emotional disturbances the tips of the digits become pale and exsanguinated In the beginning of the attack the spasm of the vessels is intermittent and can be seen best

in the finger nails, where there will be alternative waves of whiteness and pinkness of the nails but when the digits become bloodless the nails are similarly affected. The phase of local syncope is followed after a period by a cyanotic phase that appears slowly and lasts longer. The digit affected becomes gradually bluish, then purplish and finally blue-black. After some time the normal color returns. Not all the toes may be affected, and one digit may be in the phase of syncope while others may be cyanotic. The subjective sensations vary from itching, burning and other minor sensations to excruciating pain during an attack. Usually the hands are more severely affected than the feet.

Raynaud's Phenomenon vs. Raynaud's Disease
The factors which indicate the true disease are:
1. Attacks of color changes precipitated by (*a*) Cold (*b*) Emotions
2. Symmetrical
3. Sex-females
4. No sign of occlusive vascular disease
5. Gangrene
6. No evidence of disease of central nervous system
7. Skin is tight
8. Bone changes seen in roentgen-ray
One should avoid cold and the pneumatic tourniquet

RELATION OF THROMBOSIS AND EMBOLISM

Postoperative venous thrombosis occurs in episodes. If this occurs in a small vein, part or all of the thrombus may detach soon after its formation to become a small embolus. If it is not detached or if only part of it is detached, the clinical signs and symptoms of thrombophlebitis develop in the involved vein. A second episode according to Allen may occur in which the thrombosis propagates into a larger more proximal vein and this episode may be characterized by detachment (a larger or fatal embolus), by the development of thrombophlebitis in this vein, or by a small non-fatal embolus and thrombophlebitis. If the first episode of thrombosis occurs in a large vein such as the iliofemoral, the first and only signs of its occurrence may be a sudden fatal embolism, iliofemoral thrombophlebitis may develop which can be recognized clinically, or a small fragment of the thrombus may be detached to form an embolus and iliofemoral thrombophlebitis may develop. Thrombosis may occur in both legs simultaneously or episodes may occur first in one leg and later in the other or in veins in other parts of the body. At the onset of any episode of thrombosis embolism may occur. After thrombophlebitis has developed and existed for

more than three or four days, the thrombus does not detach to form an embolus, but embolism may occur if a new thrombus forms in a proximal vein or in a vein elsewhere in the body.

Hourans reported an instance of severe pain and local thrombosis resulting from the introduction of a 50 per cent compound diodrast solution into the lesser saphenous vein.

Small arteriovenous fistulas of the extremities as a rule do not warrant operative repair and may, within a year after the injury, heal spontaneously.

The accepted treatment for fistulas of the anterior tibial artery and vein is excision of the aneurysm and ligation of the proximal and distal arteries and veins with all collateral communications. However, in view of the success that Murray of Toronto has had in vascular surgery since using heparin, Gamm did a ligation of a vein with lateral arteriorrhaphy. This was followed by preservation of the pulsation.

AFFECTIONS OF VEINS

BARKER'S CLASSIFICATION OF DISEASES OF VEINS*

Obstructive	Intrinsic	Inflammatory: thrombophlebitis Neoplastic: direct invasion
	Extrinsic (pressure)	Gravid uterus Neoplasms Arterial aneurysms Anomalies Trauma
Non-obstructive	Valvular	Primary varicose veins
	Traumatic	Arteriovenous fistula Rupture
	Congenital	Arteriovenous fistula Phlebectasia Hypoplasia
	Degenerative	Phlebosclerosis

VARICOSE VEINS

Varicose veins are dilated veins, whose valves have become incompetent, and have undergone secondary changes, such as fibrosis, tortuosity, sacculation, and elongation, resulting from back pressure and stasis.

Etiology.—Varicose veins occur in persons who are on their feet for long hours. In males, they may be due to hard work such as lifting. In females, pregnancy or intra-abdominal tumors are frequent causes. Other causes include garters, obesity, and debilitating states. They often develop in early adult life. There is occasionally a familial predisposition.

The superficial veins of the leg are involved more frequently than

* Courtesy of the Proceedings of Staff Meetings of The Mayo Clinic.

the deep. According to De Takáts, the cardinal feature is an increase in venous pressure. This arterializes the vein, which responds to the pressure with hypertrophy of all of its layers followed by dilatation, which in turn causes the muscular coat to disappear almost entirely.

Symptoms.—Aside from noticing the bulging, tortuous veins in the legs, the patient usually complains of a feeling of fatigue in the legs. There may be some mild pain, or a "drawing" sensation. Some complain of a "feeling of weight." There may be swelling of the ankle.

Diagnosis.—The physiological status of the superficial and communicating veins is best determined by the Trendelenburg and Perthes' tests.

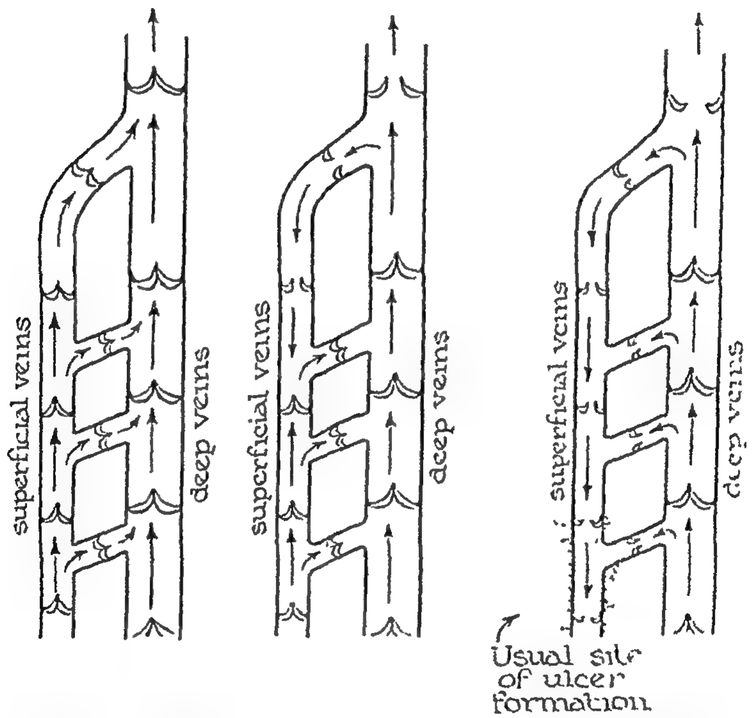


FIG. 327.—Graphic illustration of direction of venous flow in the superficial and deep veins, both in the normal state and in the case of extensive varicose veins with ulcer formation (McPheeters and Merkert, courtesy of Jour. Am. Med. Assn.)

The Trendelenburg test is done in the following manner: The limb is elevated above the level of the body to empty the distended veins, and a constrictor applied about the thigh. The patient is then instructed to stand up. In a normal leg, with the constrictor in place, the veins fill slowly from below, from forty-five to sixty seconds usually being required for the occurrence of filling by way of the capillaries. If the constrictor is removed suddenly, there is no visible downward rush of blood in the saphenous vessels. This state, indicating normal function of the valves in both the saphenous trunks and the communicating veins, is designated as a "negative" Trendelenburg test.

A visible and palpable downward rush of blood in the saphenous veins on removal of the constrictor indicates that the valves in the saphenous trunks are incompetent and that the direction of flow in these veins has been reversed This is termed a "positive" Trendelenburg test If the valves in the perforating veins are also incompetent, the veins fill rapidly from below while the constrictor is in place When such filling occurs within thirty seconds, it is usually indicative of regurgitation from the deep veins by way of the perforating veins This condition associated with incompetence of the saphenous valves is called a "doubly positive" Trendelenburg When the Trendelenburg test is positive it is safe to assume that the deep veins are patent

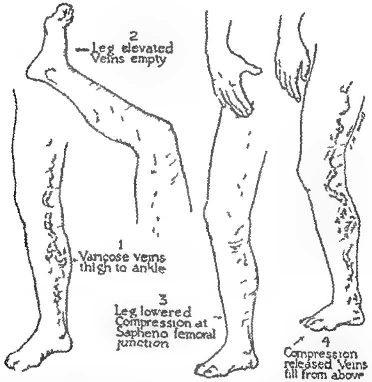


FIG 328 —Trendelenburg test The leg is first elevated to empty the vein and compression is applied Enough pressure is exerted to collapse only the superficial veins The patient then stands up while the pressure is maintained Note the collapse of the veins below the knee The fourth sketch shows the leg immediately after the pressure of the hand has been released Note the sudden filling of the veins from above (Christopher s *Textbook of Surgery* G De Takats courtesy of W B Saunders Company)

Perthes' Test —The Perthes' test determines the patency of the deep vessels According to De Takáts, if a pressure of from 30 to 50 mm of mercury is forced into a blood-pressure cuff applied around the thigh so as to obliterate only the superficial veins and the patient is asked to walk to and fro, the varices will diminish in size, while he walks and when the pressure cuff is suddenly deflated the veins will fill up from above This test demonstrates a flow from the superficial into

the deep veins into which the blood is sucked by muscular action. Emptying of the veins by gravity when the limb is elevated while the constrictor is in place indicates that the deep veins are patent.

Visualization of Peripheral Veins.—The simplest method of visualizing a peripheral vein roentgenologically in the living subject consists in making a roentgenogram after injecting a radiopaque substance directly into the vein. Allen and Barker use thorium dioxide solution. Pomeranz and Tunick injected skiodan into varicose veins for fluoroscopic visualization and observed the circulation of the blood in diseased veins and its variations during changing mechanical conditions. By the use of stereoscopic films the physical condition of the veins may be recorded.

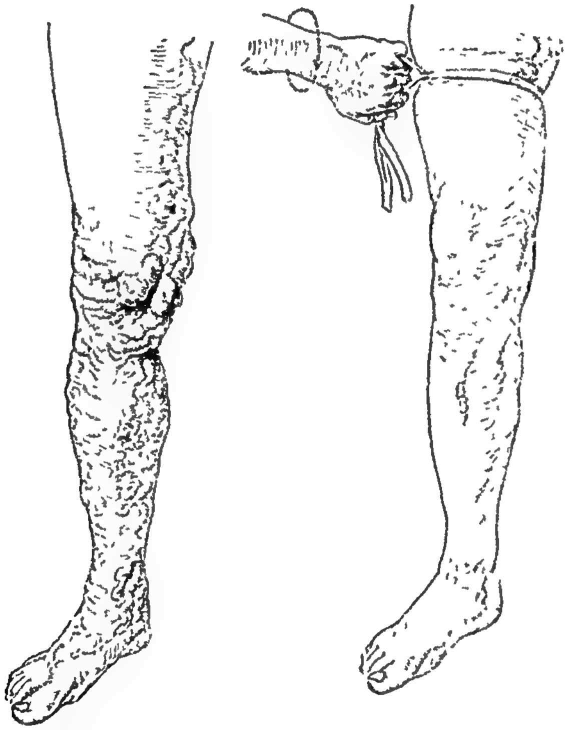


Fig. 320.—The Trendelenburg test. On the left, the varicose veins. On the right the use of a constricting bandage to prevent the flow of blood down a varicose vein Peter Bent Brigham Hospital. (Homans' Text Book of Surgery, 4th ed., courtesy of Charles C Thomas.)

The complications of varicose veins are edema, dermatitis, phlebitis, thrombophlebitis, and ulcer.

Treatment.—The non-operative treatment of uncomplicated varicose veins consists in the injection of a sclerosing agent into the varix. Sodium morrhuate is non-toxic, produces a good thrombus, and is not likely to cause a slough. Still more recently monoethanolamine compounds have been introduced.

Injection Treatment of Varicose Veins.—If the Trendelenburg test is negative, varicosities can usually be permanently ablated by the injec-

tion of sclerosing solution. If, however, the Trendelenburg test is positive, injections may not permanently obliterate the varicosities, due to eventual recanalization. When the test is positive, it is best to do a ligation operation on the saphenous vein at the saphenofemoral junction, and follow this procedure with injections of the remaining varicosities.

In choosing candidates for the injection treatment, one must be sure the deep venous circulation is adequate. Therefore, patients with edema of the lower legs and ankles must be studied in order to prove the presence of a patent deep venous circulation before undertaking injections.

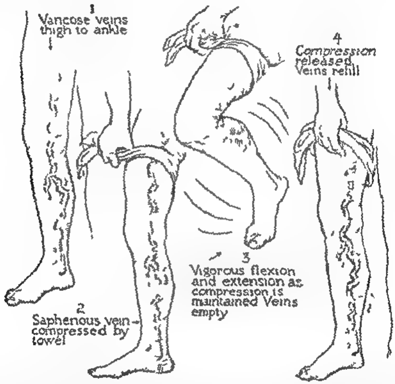


FIG. 330.—Perthes test. A tourniquet is applied with the patient in the standing position. Vigorous flexion and extension of the knee is carried out ten times. Note how the veins collapse after exercise, indicating patency of the deep vein. When the pressure is released, the veins suddenly fill from above. (Christopher's Textbook of Surgery, G. De Takáts, courtesy of W. B. Saunders Company.)

Technic of Injection.—There are many thoroughly acceptable methods for injection. The technic employed in the varicose vein clinic of Northwestern University is as follows. With the patient standing on a platform, in good light, the most prominent dilatation is selected for injection. A syringe fitted with a sharp small hypo needle is filled with 2 cc. of 2 per cent sonicin solution (sodium ricinoleate). This solution causes very little damage when inadvertently injected perivascularly. Although occasional reports of sensitivity to this solution have come to our attention, we have never seen an allergic reaction due to its use

The skin is cleaned with 70 per cent alcohol and injection is made after making sure the needle is in the lumen of the varicosity. A 1-inch square piece of felt about ¼ inch thick, and secured to a 3-inch long strip of adhesive tape, is placed, with some pressure, over the site of injection. Occasionally more than one injection per leg is made, but usually only one injection is done at a time. Patients are observed every four or five days, and are instructed to go about their usual ambulatory activities.

The Committee on Varicose Veins of the American Medical Association composed of De Takáts, Dixon, and Kern, formulated excellent working tables.

McPheeters, Merkert, and Lundblad give the following rules for the injection treatment of varicose veins: (1) Employ a sterile technic. (2) Be sure that the injection is made within the lumen of the vein (3) Stop the injection immediately when there is doubt as to whether or not the solution is going into the lumen. (4) If a perivascular injection has been made, infiltrate the area with from 10 to 20 cc. of physiological salt solution. (5) Apply sponge pressure to prevent leakage when the needle is withdrawn or if the wall of the vein has been punctured. (6) Observe the patient every other day for from six to ten days following the initial treatment, then after two months, and thereafter at intervals of from two to four months.

Although the risk of the injection treatment of varicose veins is very slight, a number of deaths from pulmonary embolism have been reported. We have never seen this occurrence.

Contraindications to Injection Treatment.—According to Zimmerman, the only absolute contraindication to injection for the obliteration of varicose veins is active inflammation of the vein. In these cases, he usually applies an Unna's paste boot, and delays injection for several weeks or months, after all evidences of the inflammation have disappeared. Other contraindications include advanced debility and senility and persistent occlusion of deep veins. Occasionally cardiac, hyperthyroid and renal disease may render treatment inadvisable.

De Takáts found that varicose veins are frequently infected from foci in the teeth, tonsils, or pelvis, or from an acute respiratory infection. Residual infection may be cleared up by repeated small doses of roentgen-ray irradiation, protein therapy, and adequate support of the limb.

Operative Treatment of Varicose Veins.—The most widely used operative treatment consists in ligation of the saphenous vein at its juncture with the femoral vein. Every small branch in the vicinity of the saphenofemoral junction must be ligated. However, in some cases ligation of the small saphenous vein in the region of the knee has to be done. On the basis of 200 ambulatory saphenous vein ligations

combined with the injection treatment for varicosities, De Takats and Quillin believe that this procedure has proved valuable. The procedure involves doubly ligating the vein, excising a portion about ¼ inch long and in most cases injecting a sclerosing agent into the distal portion. Stripping the vein is a procedure relegated to the past. Injection of persistent varicosities may have to be done even after ligation.

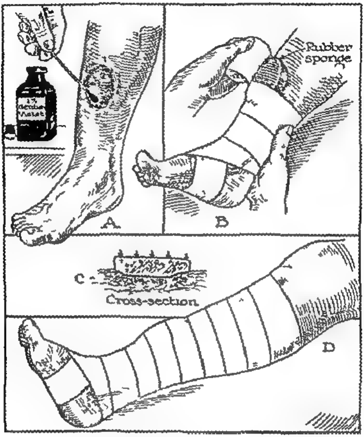


Fig. 331.—Treatment of varicose ulcer. Courtesy of Johnson & Johnson.

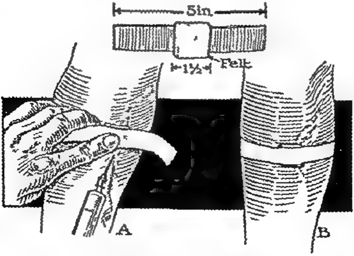


Fig. 332.—Injection treatment of varicose veins. Courtesy of Johnson & Johnson.

ULCERS OF THE LEG

Ulcers of the skin of the leg frequently follow long-standing varicose veins, in which an infection has developed. Zimmerman has shown that there is a focal phlebitis under the area of the ulcer. Ulcers are also produced and maintained by malignancy, trauma, infection, or circulatory changes. Other causes include syphilis, tuberculosis, trophic disturbances and actinomycosis.

Ulcers following varicosities may be due to the staphylococcus, streptococcus, pneumococcus or colon bacillus. McPheeters believes varicose ulcers are trophoneurotic lesions due to the stagnation of blood serum in the tissues. Frequently varicose ulcers are preceded by an area of dermatitis or eczema, which may persist after the ulcer has developed. There have been some cases of malignancy developing in the margins of varicose ulcers.

Treatment.—There have been a countless number of therapeutic suggestions for ulcers. However, when they are all evaluated they point to one conclusion, namely, mild, elastic support. This can be accomplished most effectively by Unna's paste boot. The paste is made according to the following formula:

Zinc oxide	4 parts
Gelatin	4 "
Glycerin	10 "
Water	10 "

(De Takáts and Quillin use 1, 2, 3, 4 parts respectively.)

These ingredients are mixed, placed in the inner compartment of an ordinary double boiler, and heated. The mixture should not be heated much above the melting point of the glycerin. At the time of application the paste should be of consistency of thick cream and not too hot.

The boot should be applied after at least one night of rest in bed, before the patient has been allowed out of bed in the morning, and after the part has been elevated at least five minutes to drain the limb of excessive edema. If the foot and leg are hairy, they should receive preliminary shaving.

The application is made with the patient lying supine. (Fig. 335.) The first step consists in making a turn and a half of a loose-meshed gauze roller bandage about the foot at the bases of the toes and another turn and a half about the leg just below the knee. The bandage should be about 2 inches wide.

The paste is applied directly to the skin or over a layer of stockinet by means of a 2-inch paint brush from the region of the bases of the toes to the bend of the knee. No portion of the surface is exempt, not even open ulcerated areas, the paste being carried almost to the outer edges of the two bands of gauze just previously applied. As soon as the initial layer of the paste has been applied to the skin surface, a layer or two of loose-meshed roller bandage or crinoline is applied

directly over it This layer completely coats the area previously covered by the paste No folds of roller bandage or "reversed turns" are permitted At the places where folding or "reverse turns" would be required, the bandage is cut with a pair of scissors and the winding resumed at the desired angle The bandage, like the original layer of paste extends from the bases of the toes to the bend of the knee and covers the foot and leg, including the heel A second layer of paste is applied over the layer of gauze bandage, and over this another layer of gauze bandage

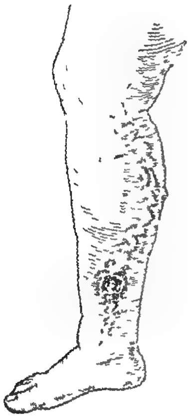


FIG 333

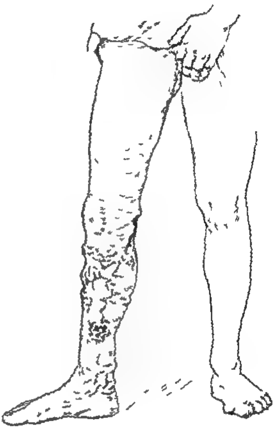


FIG 334

FIG 333 —A varicose ulcer superimposed upon a single large varicose vein In such a case removal of the vein to a point just proximal to the ulcer would cause it to heal permanently (Homans Text Book of Surgery 4th ed courtesy of Charles C Thomas)

FIG 334 —A varicose ulcer in the midst of a wide area of induration *In such a case* removal of the varicose veins alone might not prove curative and excision of the indurated area is indicated The sacculation over the saphenous opening is evident but no varicose veins are visible in the thigh (Homans Text Book of Surgery 4th ed courtesy of Charles C Thomas)

As a rule about 5 layers of gauze and 7 layers of paste are required The last layer should consist of paste The entire boot should be allowed to remain exposed to the air until the surface has dried to such a degree that it is no longer sticky When almost dry, the surface of the boot may be dusted over with powdered talcum

McPheeters and Merkert use a rubber sponge which they call a

"rubber heart" because, when the patient is walking, the sponge passively compresses the tissues and with each systole, pumps serum, lymph and venous blood from the tissues and small blood-vessels. Their rules for the treatment of varicose ulcer with the rubber sponge and a resilient bandage are as follows:

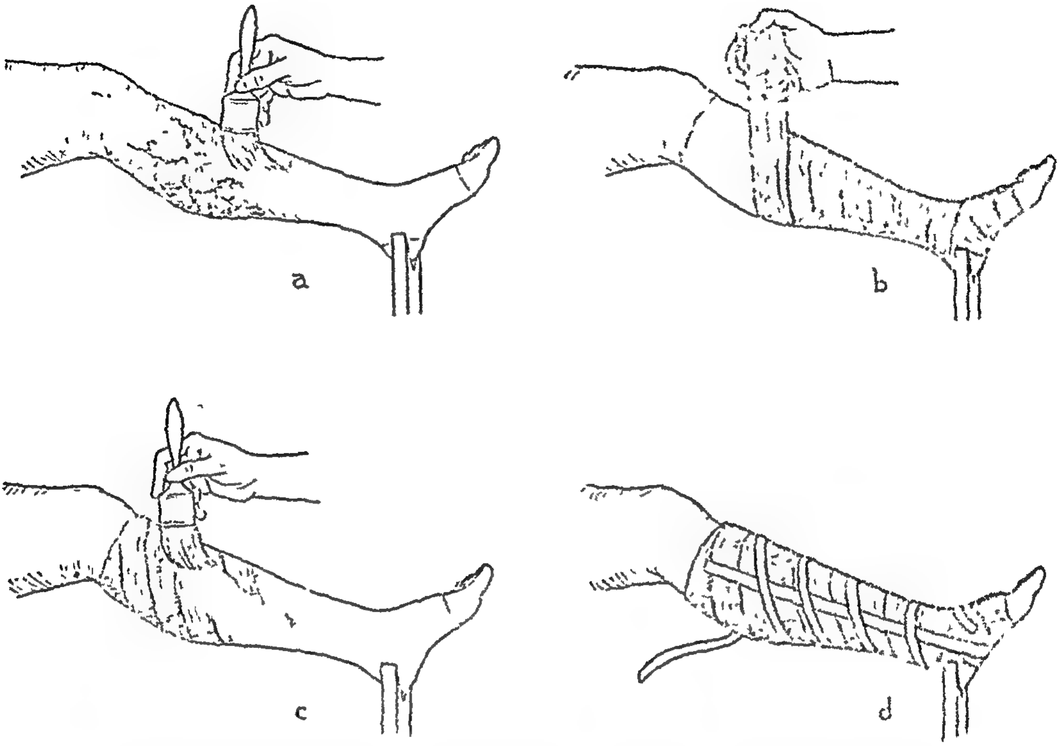


Fig 335.—Application of Unna's paste boot. *The paste consists of zinc oxide, 100 gm.; gelatin, 100 gm.; glycerin, 100 cc.; water, 200 cc.* The zinc oxide is mixed with enough water to make a thick paste, then the glycerin is added while the mixture is being stirred. The gelatin is softened in cold water and the water is squeezed out as quickly as possible The gelatin is heated on a water-bath and while being constantly stirred the zinc oxide and glycerin mixture is added to it. When the paste has cooled, it is cut into cakes weighing 8 ounces each The leg is painted from toe to knee with paste which has just been melted in a water-bath. A bandage of 3-inch gauze is placed over the paste, all folds being avoided A second layer of paste is applied in the direction of the bandage. Then a second layer of gauze, a third layer of paste and finally a third layer of gauze are applied. The bandage is then secured with strips of adhesive tape. The entire paste boot is renewed every two or three weeks (Christopher's Textbook of Surgery, G De Takáts courtesy of W. B. Saunders Company.)

1. Cleanse the skin and ulcer area with gauze wet with benzine.
2. Apply 10 per cent silver nitrate to the ulcer.
3. Apply a mild ointment to the ulcer area.
4. Apply several layers of fluffed gauze.
5. Cover with 4 layers of sheet wadding or cellucotton
6. Select a rubber bath sponge of good grade (the firmest possible) which is 1 inch larger than the ulcerating area.
7. Bandage this in place very carefully with a 3-inch gauze bandage
8. Apply a 4-inch resilient bandage firmly from just below the knee to the toes over the sponge and dressing. Apply it as a double figure-of-eight about the foot and ankle.

The more the patient walks with the leg thus bandaged the quicker the ulcer will heal. The sponge and bandage should not be applied to a bed patient. The dressing should be changed every forty-eight hours.

In mild cases, an elastic stocking may serve the same purpose as an Unna's paste boot. For deep, suppurative ulcers, gentian violet or crystal violet jelly can be applied, and the Unna boot applied directly over it.

A skin graft may be necessary. In the cases of ambulatory patients this should be followed by the immediate application of a bandage. The graft is applied as follows. Five or six small strips of skin from 1 to 2 mm. wide and from 10 to 12 cm. long are taken from the thigh and by means of a fascia needle are sewed into the ulcer in lattice fashion without regard to the position of epithelial surface.

Diathermy has yielded satisfactory results in the treatment of trophic ulcers, such as may be due to a peripheral nerve lesion, the multiple neuritis of leprosy, spondylolisthesis, herpes, syringomyelia or spina bifida.

PHLEBITIS AND THROMBOPHLEBITIS

BARKER'S CLASSIFICATION OF TYPES OF THROMBOPHLEBITIS*

Local	Chemical Traumatic: early and delayed Varicose: spontaneous Infectious and suppurative
Hematogenic	Blood dyscrasias
Secondary	Postoperative Postpartum With various infectious diseases: pneumonia, typhoid fever, influenza
Primary	Thrombo-angiitis obliterans Idiopathic

* Courtesy of the Proceedings of Staff Meetings of The Mayo Clinic.

Phlebitis and thrombophlebitis are rather common complications of varicose veins. The clotting which occurs in a varicose vein usually begins in a sacculation, and therefore is due to two factors: an inflammation of the vein wall lining, plus slowing of the current. The clot may spread and occupy the main stem of the vessel from the groin to the foot.

The thrombosed vein stands out as a solid cord, and may not give gross evidence of being infected. However, the skin covering the vein is reddened, and a zone of induration may extend for a short distance on either side. Some tenderness is usually present. As the inflammation subsides, the clot is gradually absorbed, and the vessel resumes its normal appearance. If the infection is very active, abscess formation may occur.

According to Homans, a distinction should be made between throm-

bophlebitis of varicose veins and thrombophlebitis of veins not previously varicose. In the former there is little or no edema, while in the latter, edema is a prominent feature. He believes that the lymphatic trunks which invariably accompany larger veins, and whose involvement in the inflammatory process is the cause of general *edema of thrombophlebitis* (in veins not previously varicose), are driven into new regions by the slow sclerosis of the developing varix.

Thrombophlebitis in veins not previously varicose probably originates in the pelvis, and is most commonly due to *puerperal sepsis* or gynecological operations. Other causes are inflammation of the prostate and bladder and the pelvic bowel in either sex. In some cases no infection or trauma can be traced.

These clots may extend as high as the vena cava.

Pain and fever are the typical early symptoms of thrombophlebitis in veins not previously varicose. The pain may not increase much when the leg is moved, but the movements are slow because of a feeling of heaviness. In a short time the whole limb becomes swollen and white (phlegmasia alba dolens).

The edema following thrombophlebitis of the extremities is more often of venous rather than lymphatic origin. Cohnheim and Zimmerman have independently shown that ligation or extirpation of all of the lymphatics from an extremity fail to produce edema of the limb.

Other causes of thrombophlebitis include trauma, syphilis, dehydration, and changes in the composition of the blood.

Treatment of Thrombophlebitis of Varicose Veins.—The usual treatment consists of rest in bed, elevation of the leg, and the application of an ice bag. Some prefer heat. For acute thrombophlebitis of the leg and foot, I recommend the application of a well-fitting plaster-of-Paris cast to immobilize muscles, tendons, and skin which always cause irritation when in action. A window may be cut out over the affected area for inspection and irradiation.

Another method is to enclose the leg, up to the upper limit of the thrombus, in an elastic bandage, and permit the patient to get about.

Ochsner and De Bakey believe that many of the symptoms and signs of thrombophlebitis are due to vasospasm of the arterial and venous systems and that the vasoconstricting impulses originate in the thrombophlebitic segment. The vasospasm produces increased filtration pressure, relative anoxia of the capillary endothelium and diminution in the flow of lymph, *all of which increase the amount of* perivascular fluid.

By interrupting the vasoconstrictor impulses with procain hydrochloride infiltration of the sympathetic ganglions, there is produced a reëstablishment of the normal exchange of intravascular and perivascular fluids.

Treatment of Thrombophlebitis in Veins Not Previously Varicose — Treatment of this condition is for the most part conservative and expectant regardless of whether the disease is confined to the great saphenous or is in the iliac and femoral veins. Bed rest, elevation of the affected limb, and heat are the usual therapeutic measures. In the case of saphenous vein phlebitis, some advocate ligation at the saphenous opening to prevent embolism and toxic absorption. Others condemn this method on the basis that the surrounding lymphangitis should preclude any surgery in that region.

The patient is kept in bed and the limb elevated until the systemic reaction disappears and the limb assumes a normal appearance. Then exercises and massage are gradually instituted, but should be immediately discontinued if the edema reappears. An elastic bandage or Unna's paste boot should be applied while the patient is up and about.

For the complications of varicose veins, including ulcers, eczemas, indurations and localized phlebitides, treatment is largely limited to the use of gentle elastic supportive bandaging. Zimmerman, *et al.*, recommend the Unna paste boot, plus the management of the underlying veins.

Varicosities of the lower extremities are classified into three distinct groups by Heyerdale and Stalker.*

Classification of Varicosities of the Lower Extremities

Group	*Varicosities*	*Great or small saphenous system*
I	Spider bursts, rocket bursts, telangietatic veins	Competent
II	Mild or moderate varicosities	Competent
III	Mild, moderate, or marked varicosities	Incompetent

Test Dose.—To safely approach the obliteration of any type of varicosities, particularly those of the second and third groups, a "test dose" or injection should be given at least four hours, and preferably twenty-four hours prior to therapy. 0.5 to 1 cc. of a 5 per cent solution of sodium morrhuate, or a like amount of 5 per cent solution of monoethanolamine oleate injected into a varicose vein of medium size, is the appropriate amount. Ligation and division of the offending vein, and injection of a sclerosing agent into it, must be meticulously performed to obtain the greatest percentage of permanent results.

* Heyerdale and Stalker. Ann. Surg. December 1941.

Technic of Division and Ligation; Technic of the Sclerosing Solution into an Incompetent Great Saphenous Vein.—The site of the fossa ovalis, and consequently of the saphenofemoral junction, is determined after the patient is on the operating table, and draped for the operation. The point of maximal pulsation of the femoral artery at the lower border of Poupart's ligament is determined. One of them measures downward, approximately 1 inch (2.5 cm.), and then medialward approximately 1 inch. A scratch mark is made on the skin at this site which, in the majority of instances, has proved to lie directly over the fossa ovalis. After the region has been infiltrated with a 1 per cent solution of procaine hydrochloride, an ample incision is made parallel to Poupart's ligament; the marked site of the fossa ovalis is used as the middle point of the incision. The incision is carried down to the superficial fascia and a self-retaining mastoid retractor is inserted.

The great saphenous vein lies beneath the superficial fascia and superficial to the fascia lata of the thigh. The superficial fascia is incised in a line parallel to that of the incision. Occasionally, blunt dissection is necessary to expose the vein when it is surrounded by excessive areolar tissue. The great saphenous vein is separated from its bed for a short distance and a curved clamp is passed beneath it.

The vein is doubly ligated with chromic catgut, and a curved forceps is placed on the vein just proximal to the ties. The vein is then divided between the ligature and the forceps, and the distal portion is allowed to retract downward.

The three uppermost tributaries of the great saphenous vein, namely, the superficial circumflex iliac; the superficial epigastric; and the external pudendal veins, can be exposed by making traction on the proximal stump of the great saphenous vein and, by carefully stripping from it, with the index finger, the surrounding loose areolar tissue as far proximally as the femoral vein.

From a therapeutic standpoint, varicosities of the lower extremities may be classified, simply, into three groups: (1) Spider bursts, rocket bursts, telangiectatic veins; (2) mild or moderate varicosities without associated demonstrable incompetency of the great or small saphenous system; and (3) mild, moderate, or marked varicosities associated with incompetency of the great or small saphenous system or with incompetency of both systems. On the basis of this classification, Heyerdale and Stalker base their method of therapy. Approximately 50 per cent of patients treated have demonstrable incompetency of the great saphenous system. In such cases, the essential steps in treatment are: (1) ligation and division of the great saphenous vein at the saphenofemoral junction; (2) separate division and ligation of the tributaries of the saphenous vein; and (3) injection of a sclerosing solution into the saphenous system.

Most ulcers of the leg are associated with disturbances of the venous circulation. The two principal underlying conditions are varicose veins and deep vein thrombophlebitis. These conditions seem to be inflammatory in origin, and a sequence of events may be traced from initial phlebitis, through the stages of induration and cicatrization to the eventual ulcers. Both groups of ulcers therefore are phlebitic in origin and the essential tissue change in both is inflammation with subsequent fibrosis and cicatricial ischemia.

Of all the remedies offered for ulcers of the leg, gentle mechanical pressure has proved most effectual, and provides the mainstay of any therapeutic regimen. Eradication of concomitant varicosities and attention to associated local and general conditions are also included. While skin grafts are theoretically a logical solution one rarely has recourse to them because of the satisfactory results obtained by purely ambulant methods.

EDEMA OF THE FOOT AND ANKLE

There are many causes for swelling of the ankle. It is necessary to determine the cause before any therapy is instituted.

Local causes include: trauma, such as sprain, fracture, dislocation and soft tissue injury, varicose veins, thrombophlebitis of either varicose veins or veins not previously varicose, postphlebitic edema, lymphangitis, tenosynovitis, osteomyelitis, elephantiasis, soft tissue infection, reflex dystrophy, and interference with local circulation.

Systemic causes include: cardiac incompetency, renal disease, hypothyroidism, diabetes mellitus, postural hypotension, general debilitation, avitaminosis, infections (causing phlebectasia), angioneurotic edema, intermittent hydrarthrosis, allergy, chronic hereditary edema (Milroy's disease), elephantiasis, hypoproteinemia, variations in water retention, obesity, calcium deficiency.

A careful search should be made not only for the cause or causes of edema, but other types of swelling should be differentiated. These include such lesions as lipoma, arteriovenous aneurysm, malignancy, infections, etc.

The treatment is directed to the cause, and is discussed under the heading of the causative disease.

Phlebectasia of the Leg.—According to Taylor and Barker, phlebectasia of the leg is due to an infection. The symptoms are a uniform slowly progressive swelling of the entire leg which is accompanied by a sense of heaviness following prolonged exercise. There is no pain. The skin is usually cyanotic and may be pitted. An elastic stocking affords moderate relief.

Angioneurotic Edema.—Angioneurotic edema is a familial and hereditary condition characterized by periodic swellings of joints beginning

at birth or at the age of puberty and continuing through life. Its causes are combined nervous, allergic, and vascular factors. In its onset and course, it is very much like urticaria. The treatment of the acute attack is symptomatic and palliative. Firm support by bandage is of value.

Idiopathic or Localized Postural Edema.—Idiopathic edema of the ankle is usually amenable to adhesive strapping of the ankle and foot at intervals of about a week for four weeks, followed by the application of an elastic stocking. The pure Para-elastic bandage is helpful. High shoes are beneficial in relieving the soft tissues of the "water logging." Mechanical disturbances should be corrected, and massage and contrast foot baths prescribed. Small doses of thyroid are usually indicated. Large doses of calcium are advised.

Chronic Hereditary Edema (Milroy's Disease, or Trophedema).—This is a firm edema due to a hereditary disturbance of the blood and lymph circulation in one or both lower extremities. It may be present at birth or appear during puberty. As a rule, it is not accompanied by pain or constitutional symptoms. There are no demonstrable signs of venous or lymphatic obstruction. It may be anaphylactic in nature like some cases of intermittent hydrarthrosis. Milroy thought that it might be due to a local venous obstruction or thrombosis, a lymphatic obstruction, or a defect in the activity of the blood-vessels or lymphatics dependent upon a disturbance of the nerve supply.

Elephantiasis.—Lymphatic elephantiasis is a chronic progressive enlargement of a portion of the body due to hyperplasia of the lymph vessels, chronic edema of the affected part and hyperplasia of the connective tissue of the skin and subcutaneous tissues. It is characterized by inflammation and obstruction of the lymphatics with resulting hypertrophy of the skin and subcutaneous tissues.

Kondoleon's operation establishes a connection between the superficial and deep lymphatics by breaking the fascial wall between the muscles and subcutaneous tissues. Wide wedges of skin, fat and fascia are removed from the inner and outer aspects of the entire length of the affected limb. Walters' modification of Sistrunk's technic is also recommended.

REFLEX DYSTROPHY OF THE LOWER EXTREMITIES

According to De Takáts, a mild trauma, usually a blunt injury, or a low-grade infection of traumatic or non-traumatic origin, a partial injury to a nerve, frost-bite, or a burn, may be followed by a peculiar vasomotor and trophic disturbance designated as acute atrophy of bone, traumatic angiospasm, traumatic vasospasm, chronic traumatic

edema, peripheral acute trophoneurosis, reflex nervous atrophy, reflex nervous dystrophy, or post-traumatic osteoporosis

After the acute symptoms of a comparatively mild injury have subsided, there appears a hard, non-pitting edema which is frequently accompanied by paroxysms of pain. The skin is glossy and has a bluish tint, and the extremity is sensitive to draughts, changes in temperature, and superficial and deep pressure. Sensory disturbances are indefinite. Frequently there is a glove-like hypesthesia which does not follow any sensory nerve distribution. At first the muscles are hypertonic because of increased reflex irritability, but later they become atonic. Their electric excitability is diminished although of normal quality. The temperature of the skin is at first higher and later lower than that of the unaffected extremity. Profuse sweating occurs. Sometimes an increased growth of hair or a weeping eczema appears. The nails become brittle and ribbed. The bone shows a characteristic spotty atrophy which may later become diffuse. The growing bone may be retarded in its growth, the epiphyseal lines closing prematurely. Shrinkage of the capsules of the joints causes severe pain on movement, and mobilization of the contractures aggravates the condition.

Reflex dystrophy is often mistaken for atrophy of disuse, artificial edema, anxiety neurosis, or malingering. It must be differentiated from venous and lymphatic edema, inflammatory reactions occurring around carpal and metacarpal fractures, tuberculous and pyogenic osteomyelitis, and infection of the tendon sheaths and fascial spaces. In the lower extremity, spasmodic flat-foot may simulate the condition.

De Takáts has described 9 cases of reflex dystrophy of the extremities. The causes were: (1) a mild injury to the soft tissues, (2) pelvic lymphangitis, (3) an axillary thrombosis, (4) nodular phlebitis of the veins, (5) a low-grade infection of the soft tissues, (6) a mild injury to the foot, (7) lymphangitis of a toe, (8) an injury to the wrist from strapping on the operating table, and (9) an injury to the middle finger. In the case in which the condition followed an injury to the middle finger there were marked herpetiform eruptions in addition to an increased blood flow. In all of the cases the local alteration of the tissues maintained an exaggerated nutritional reflex leading to vasomotor and trophic phenomena. In 2 cases sympathectomy was performed with cessation of the symptoms.

CHAPTER XXVIII

DEFICIENCY, METABOLIC AND GLANDULAR DISEASES

RICKETS INVOLVING THE FOOT AND ANKLE

RICKETS is a systemic disturbance of metabolism due to a deficiency of vitamin D which is manifested by deficient calcification of osteoid tissue. It occurs usually between the sixth and twenty-fourth months of infancy. If not corrected, it results in softening and bending of the bones, enlarged epiphyses, deformities of the chest, kyphosis, dwarfism, and other defects.

Rickets occurs more frequently in cities than in rural districts. Premature infants are especially susceptible.

Pathology.—The striking pathological changes of rickets are imperfect endochondral ossification, excessive resorption of the inner layers of the bones, fibrous tissue *transformation of bone marrow, and* osteoid tissue formation due in part to decalcification and in part to metaplasia of cartilage and fibrous tissue.

Etiology.—Rickets is due to an inadequate supply or defective utilization of vitamin D, the filtering out from the sunlight of the ultra-violet rays of the shorter wave lengths by window glass, clouded skies, smoke palls over manufacturing cities, and heavily pigmented skin Congestion of population, polluted air, damp, unclean living quarters, frequent exposure to infection, prolonged illness, lack of exercise, and unhygienic conditions are intensifying factors.

Thus, the deficiency may be due to inadequate diet, defective utilization by the body or insufficient exposure to sunlight. Sunlight irradiates the sterols in the skin, giving the body a direct source of vitamin D.

Rôle of Vitamin D.—Deficiency of the fat-soluble vitamin D is the preponderating factor in rickets. Mellanby discovered that rickets could be produced in puppies by depriving them of this vitamin Cod-liver oil, a natural specific for rickets, contains 200 times as much vitamin D as butter. The *only other natural sources of the vitamin* are egg-yolk and various fish oils.

Hess, Steenbock, and Nelson, working independently, demonstrated that most foods can be endowed with the antirachitic property by being irradiated with ultra-violet rays. The substance "activated" is an ergosterol. Irradiated ergosterol is 100,000 times as effective against rickets as cod-liver oil. Yet, according to Hess and Lewis, not more than 1 or 2 per cent of this substance is "activated." The fat-soluble vitamin D has been isolated in pure form.

Rôle of Ultra-violet Rays —Hess and Weinstock emphasized that absence of sunlight does not produce rickets if the nutritional requirements are met, pointing out that lack of sunlight and rapidity of growth combine throughout intrauterine life, yet rickets does not develop, owing to the superiority of placental nutrition

Rôle of Calcium-phosphorus Balance —With the development of human rickets, the normal amounts of phosphorus and calcium in the blood are lowered from 10 to 11 mg and 5 to 6 mg, respectively, to approximately 8 mg and 2 5 mg per 100 cc of the blood

Findlay stated that a child may get ample calcium in its food and *still have bones which are poor in this element* He offered three explanatory possibilities (1) a failure of the calcium to be properly transported to the bones or deposited in them, (2) a failure of absorption of calcium from the intestine, (3) a fault in the growing centers so that they cannot retain it Findlay as well as Orr and his co-workers, inclined toward the explanation of a diminished absorption of calcium from the intestine

Orr, Holt, Wilkins, and Boone found in metabolism studies that an excess either of calcium or of phosphorus in the diet influences unfavorably the absorption of the other from the intestine

These studies emphasize the importance of a disturbance of the *normal physiological balance between phosphorus and calcium in the* blood Under the influence of ultra-violet rays or of irradiated foods or those naturally containing the fat-soluble vitamin D the low inorganic phosphorus in the serum is increased to normal or slightly above and fresh deposits of calcium appear in the bones

Symptoms —The symptoms appear first in the nervous system, then *in the muscular system, and lastly in the bones The constitutional* symptoms are restlessness, excessive perspiration, digestive disturbances, constipation with flatulence, impairment of the circulation, bronchitis, and generalized muscular weakness The child's tissues are tender to pressure, and some of its joints may be sensitive to movement The skeletal muscles and ligaments are relaxed The ability to stand and walk is delayed, and the movements are slow

Moore states that the skeletal signs of rickets appear in various bones *at the time of their most rapid growth* In the first year, the chief manifestations are in the bones of the chest, in the second year, and at puberty, in the bones of the extremities His study demonstrates the direct relation of rickets to genu valgum and static flat-foot He believes that the amount of lateral mobility in the knee is an accurate index of the degree of leg rickets in the early stages, and later demonstrates the progress being made toward cure Perfect legs are straight and parallel from the knees down

Large diapers on rachitic children favor the production of bow-legs. Frequent carrying of the child over one hip may cause a knock-knee on one side and a bow-leg on the other. Anterior bowing of the legs is commonly due to the seating of a rachitic infant in a large chair, the front edge of which acts as a fulcrum on the soft bones. In the rachitic child the epiphyses of the leg bones are enlarged, especially above the ankles. Rachitic deformities are chiefly fostered by the congestion of the epiphyses, the relaxation of the protective joint structures, and gravity.

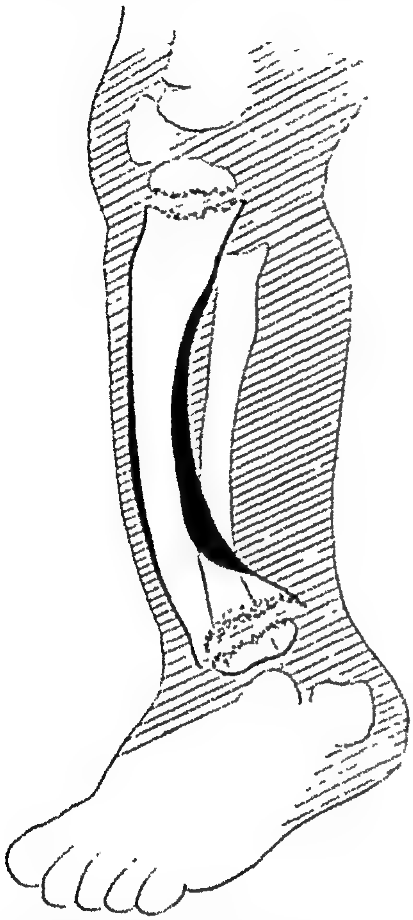


Fig. 336.—Rachitic changes in lower end of tibia. (Note thickening of concave surface of tibia.)

Roentgen Observations. — The roentgen appearances of the long bones are characteristic. The following description is based upon Lovett's study of over 500 roentgenograms. In the early stage, the diaphysis is seen to contain less than the normal amount of calcium; the ends of the diaphysis look frayed out. The epiphysis casts little if any shadow, while the center of ossification is small or absent. The joint appears shrouded in a haze. In more severe early cases, the *diaphysis* shows *general bone* atrophy and pronounced periosteal thickening. (See Fig. 336.)

The second stage is one of systemic reaction to the disease. Signs of returning ossification are seen. Deformity appears. The shadow of the epiphysis becomes more marked; it has a ragged margin, and the area of shadow looks mottled because of spotty calcification. The shadow of the diaphysis is also more definite and the ends broaden. The region next to the epiphysis, which is the area of greatest disturbance, is streaked longitudinally. At the epiphyseal end of the shaft there is generally increased density reaching about $\frac{1}{4}$ inch from the epiphyseal line and rather sharply delimited at the margin farthest from the joint. At the lower end of the diaphysis, next to the epiphyseal line, there often appears in the late second stage a transverse white line representing an increased deposit of calcium phosphate. There is cortical thickening on the concave side [illegible] notice the

chiefly in the bone that has curved. This is of endosteal origin, and persists into the stage of cure. Light areas in the shaft indicate lessened bone deposit, and heavy lines, irregular development of trabeculæ. The smooth homogeneous shadow of normal bone is replaced by one irregularly streaked.

The third stage is that of convalescence. The epiphyseal shadow resumes the normal contour and homogeneous density. The marginal irregularity and a little of the mottling, however, persist. Lipping of the diaphysis enlarges the ends of the bones.

Diagnosis.—The diagnosis of rickets is based on the history, the physical findings, the roentgenograms, and the blood tests. The disease must be differentiated chiefly from congenital syphilis and scurvy, but especially from syphilis. This differentiation is illustrated in the chart, which is modified from that of Baetjer and Waters.

DIFFERENTIAL DIAGNOSIS

	Rickets	Congenital syphilis	Scurvy
Age	Very young, especially first 2 yrs.	Very young, especially first 2 yrs.	Very young, especially first 6 to 18 mos.
Joint	Intact, cloudiness involves whole joint and is present in first dentition	Intact, cloudiness involves only epiphysis and is noted chiefly in fetus and newborn infant	Intact
Epiphyseal line	Softened and spread out, saucer shaped, champagne glass type	Clear, not spread out, gouged-out area in diaphysis	Epiphysis not disturbed, but a destructive zone is formed just behind epiphyseal line (Trommer)
Diaphyseal white line	Present in some cases		
Atrophy	Present	Absent	Present, uniform in some cases
Fractures	Not frequent	Rare	Not frequent, epiphysis occasionally dislocated by hemorrhage
Periostitis	Usually absent; in severe rickets periostitis frequently associated with fractures; it diminishes with progress of disease and does not tend toward bone formation; in metacarpal bones it suggests dactylitis	Practically always present, usually excessive and tends toward ossification	Practically always present, periosteum elevated by blood
Pulmonary changes	May be marked	May or may not be present	Absent
Deformities of bones	May be extreme	Present	Not present, occasional tumor masses—hemorrhage
Periosteal hemorrhage	Not present	Not present	Frequent—very important

The differential points depend on the changes in and around the epiphyseal line and on the periosteal changes. In rickets, the changes are confined to the epiphyseal line, in syphilis the epiphyseal line and the bone behind it are involved, in scurvy, the epiphyseal line is intact

Large diapers on rachitic children favor the production of bow-legs. Frequent carrying of the child over one hip may cause a knock-knee on one side and a bow-leg on the other. Anterior bowing of the legs is commonly due to the seating of a rachitic infant in a large chair, the front edge of which acts as a fulcrum on the soft bones. In the rachitic child the epiphyses of the leg bones are enlarged, especially above the ankles. Rachitic deformities are chiefly fostered by the congestion of the epiphyses, the relaxation of the protective joint structures, and gravity.

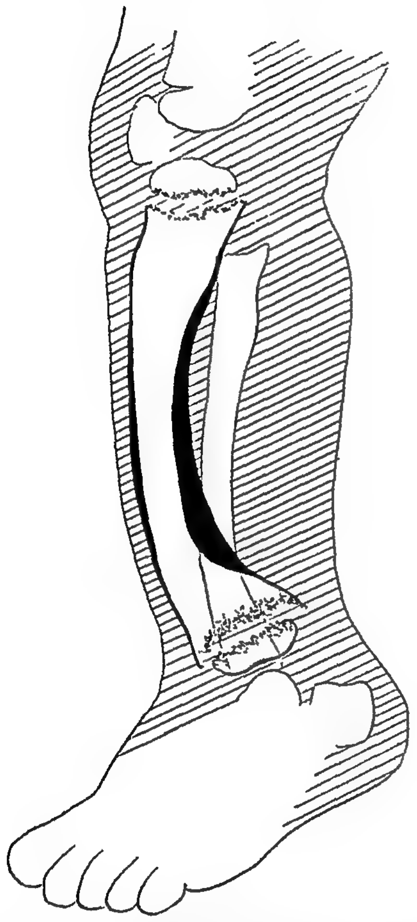


FIG. 336.—Rachitic changes in lower end of tibia (Note thickening of concave surface of tibia.)

Roentgen Observations. — The roentgen appearances of the long bones are characteristic. The following description is based upon Lovett's study of over 500 roentgenograms. In the early stage, the diaphysis is seen to contain less than the normal amount of calcium; the ends of the diaphysis look frayed out. The epiphysis casts little if any shadow, while the center of ossification is small or absent. The joint appears shrouded in a haze. In more severe early cases, the diaphysis shows general bone atrophy and pronounced periosteal thickening. (See Fig. 336.)

The second stage is one of systemic reaction to the disease. Signs of returning ossification are seen. Deformity appears. The shadow of the epiphysis becomes more marked; it has a ragged margin, and the area of shadow looks mottled because of spotty calcification. The shadow of the diaphysis is also more definite and the ends broaden. The region next to the epiphysis, which is the area of greatest disturbance, is streaked longitudinally. At the epiphyseal end of the shaft there is generally increased density reaching about $\frac{1}{4}$ inch from the epiphyseal line and rather sharply delimited at the margin farthest from the joint. At the lower end of the diaphysis, next to the epiphyseal line, there often appears in the late second stage a transverse white line representing an increased deposit of calcium phosphate. There is cortical thickening on the concave side of the bone, noticeable

chiefly in the bone that has curved This is of endosteal origin, and persists into the stage of cure Light areas in the shaft indicate lessened bone deposit, and heavy lines, irregular development of trabeculæ The smooth homogeneous shadow of normal bone is replaced by one irregularly streaked

The third stage is that of convalescence The epiphyseal shadow resumes the normal contour and homogeneous density The marginal irregularity and a little of the mottling, however, persist Lipping of the diaphysis enlarges the ends of the bones

Diagnosis —The diagnosis of rickets is based on the history, the physical findings, the roentgenograms, and the blood tests The disease must be differentiated chiefly from congenital syphilis and scurvy, but especially from syphilis This differentiation is illustrated in the chart, which is modified from that of Baetjer and Waters

Differential Diagnosis

	Rickets	Congenital syphilis	Scurvy
Age	Very young especially first 2 yrs	Very young especially first 2 yrs	Very young especially first 6 to 18 mos
Joint	Intact cloudiness involves whole joint and is present in first dentition	Intact cloudiness involves only epiphysis and is noted chiefly in fetus and newborn infant	Intact
Epiphyseal line	Softened and spread out saucer shaped champagne glass type	Clear not spread out gouged-out area in diaphysis	Epiphysis not disturbed but a destructive zone is formed just behind epiphyseal line (*Trommer*)
Diaphyseal white line	Present in some cases		
Atrophy	Present	Absent	Present uniform in some cases
Fractures	*Not frequent*	*Rare*	*Not frequent epiphysis occasionally dislocated by hemorrhage*
Periostitis	Usually absent in severe rickets periostitis frequently associated with fractures it diminishes with progress of disease and does not tend toward bone formation in metacarpal bones it suggests dactylitis	*Practically always present* usually excessive and tends toward ossification	*Practically always* present periosteum elevated by blood
Pulmonary changes	*May be marked*	*May or may not be present*	Absent
Deformities of bones	May be extreme	Present	Not present occasional tumor masses—hemorrhage
Periosteal hemorrhage	Not present	Not present	Frequent—very important

The differential points depend on the changes in and around the epiphyseal line and on the periosteal changes In rickets, the changes are confined to the epiphyseal line, in syphilis, the epiphyseal line and the bone behind it are involved, in scurvy, the epiphyseal line is intact

and all changes are just behind the epiphyseal line. In rickets, periostitis is rare; in syphilis, it is marked; in scurvy, it is frequently accompanied by subperiosteal hemorrhage. In rickets, there is atrophy and occasionally multiple fractures are found, while in syphilis and scurvy, atrophy is usually slight and as a rule there are no fractures.

Treatment.—The routine treatment includes fresh air, sunshine and liberal diet especially rich in vitamin D. These measures can be supplemented by exposure to ultra-violet ray lamps and synthetic or natural concentrates of vitamin D. According to Vollmer, rickets and tetany can be cured by the peroral administration of a single dose of 600,000 international units of vitamin D in milk. The curative effect of this treatment is more prompt than that obtained with the daily administration of small doses. The serum calcium and serum phosphorus become normal, and roentgenographic evidence of calcification shows within a week. The most impressive effect is the rapid rise of the serum calcium.

Tetanic convulsions do not recur and all other symptoms of hyperirritability usually disappear within two days without any additional therapy. No contraindication seems to exist. Vitamin D is effective also when administered subcutaneously.

Orthopædic Treatment.—Some rachitic deformities will not "correct" without orthopædic help. It is often difficult to decide when a case calls for orthopædic measures. The importance of knock-knees and bow-legs as factors predisposing to arthritis in later life should be considered. Among the orthopædic measures for the correction of rachitic deformities are the use of plaster casts, splints, and braces, and the bending or breaking of bones. Bending of bone (osteocampsis) can be done by hand or by apparatus. Breaking of bone (osteoclasis) can be done by hand or by various osteoclasts such as those designed by Stillé, Putti, and Grattan. Breaking a bone by the use of an osteotome, chisel, or gouge is called osteotomy.

During the acute stage, operation is contraindicated because it may be followed by a deformity of a type opposite to that of the deformity for which it is performed. Lovett advised that no patient should be operated on until the lower epiphysis of the tibia has become rounded with a clear outline. In the subacute stage, the bone is poorly provided with lime; it cuts like cheese and is likely to bleed profusely.

Technic of Osteotomy.—Over the point selected, a small incision is made, and a chisel is inserted. The chisel is worked back and forth parallel with the long axis of the bone. A piece of gauze is wrapped around the chisel and the instrument held firmly against the bone. By means of a mallet, the bone is chiselled about three-fourths of the way through and a "greenstick" fracture is made.

The wound is closed with catgut subcutaneously and with catgut, silkworm gut, or waxed silk cutaneously. The stockinet is then pulled down, the limb is encased in a layer of sheet wadding and roller bandage and a plaster cast are applied. As the cast sets, slight overcorrection of the deformity is obtained.

The site of the osteotomy is determined by the deformity and by roentgenograms. In the ideal osteotomy, the deformity is corrected with minimal displacement of the fragments. Haas made a series of 5 or 6 longitudinal osteotomies extending around the circumference of the bone at equal intervals. Each longitudinal section of bone between the osteotomies gives way as a separate unit, without loss of continuity, as a "greenstick" fracture. There is practically no postoperative displacement of the fragments.

Late Rickets.—This is undoubtedly a disturbance of bone metabolism due to undernutrition. The immediate cause of deformity is a disproportion between the carrying power of the bones and the loads they are forced to support. The pathogenesis, blood chemistry, and histology of late rickets class it with rickets and osteomalacia. There may be a decrease in height due to the deformities, usually knock-knees and bow-legs. Weakness is due to the mechanical disturbance. After the deformity has existed for some time, pain may appear. Roentgenograms clearly define the deformity, but may not reveal gross bony changes. The treatment is similar to that for infantile rickets except that deformities must be corrected by surgery.

Tetany.—The outstanding sign of tetany in pregnancy is muscular contracture occurring especially in the lower extremities and involving, as a rule, the gastrocnemius, soleus, and flexor hallucis longus. The Trousseau, Chvostek, and Erb phenomena may occur, but are so infrequent as to be of little diagnostic value. Richardson noted other diagnostic signs such as tingling or numbness of the extremities and localized swelling of the limbs.

OSTEOMALACIA

Osteomalacia is a disease in which the bones become soft and flexible. The etiology is unknown. The chief pathological change is a reduction in the amount of calcium in the bone. Osteomalacia and rickets may represent varying degrees of intensity of the same syndrome but having the same anatomical substratum, *i. e.*, decalcification, combined with a reaction on the part of the osteogenic elements of the bone-marrow.

True osteomalacia, according to Maxwell, is the manifestation of rickets in a person whose bones have reached maturity and is connected with a shortage of vitamin D and in the majority of cases with

an actual calcium starvation. Although characterized by osteoporosis, it has to be distinguished from hyperparathyroidism, pseudo-osteomalacia malignum and hyperthyroidism.

The fundamental process according to Hodges and Ledoux is probably identical with rickets of children where growth plays an important rôle but the unusual calcium demands of pregnancy or lactation are absent, and with senile or famine osteoporosis where diet deficiency is the sole factor. Much less close is the relationship to the osteoporosis that follows primary parathyroid dysfunction, to Paget's disease or to osteitis fibrosa cystica.

It is found chiefly in famine districts or where peculiar religious or social prohibitions keep women indoors, away from light.

Osteomalacia may occur at all ages, but the larger number of cases occur in women during the child-bearing period. However, women who have never been pregnant may suffer from it, and occasionally the disorder attacks men. When elderly people are affected the term "senile osteomalacia" is used.

The symptoms are chiefly rheumatic pains, the roentgenographic findings are softening, decalcification, deformities of the bone, and in some cases fractures. The pathological changes are decalcification of the bony framework and reversion of the resulting organic matrix and medulla to fibrocellular connective tissue. This tissue may either degenerate, and break up into débris and fat or may develop into incompletely calcified cancellous bone. The reparative change is met with in those fractures in osteomalacic bones that unite by callus which is no doubt induced by the stimulus of the injury. Bending and fractures are the two principal deformities.

The treatment is supportive plus an antirachitic diet including vitamins, especially vitamin D, and heliotherapy. Cod-liver oil, phosphorus and viosterol are of value.

SCURVY

Scurvy is a disease due to vitamin C deficiency and is manifested by subcutaneous, submucous, and subperiosteal hemorrhages as well as generalized symptoms. It occurs in children between the sixth and tenth months of life. As the result of improved prophylaxis, it has become uncommon in children. It is rare in adults.

Scurvy develops as the result of a lack of fresh foods containing vitamin C. From studies of dentin, bone matrix, and the collagen of connective tissues in connection with growth and repair Wolbach and Howe have gained the impression that the supporting tissues are unable to produce and maintain intercellular substances, and that the localized hemorrhages are due to lack of cement substances in the blood-

vessels Capillary fragility leading to the appearance of petechiæ is one of the earliest manifestations of the effects of a scurvy-producing diet In scurvy there is loosening of the attachments of ligaments and tendons

Symptoms —Babies suffering from scurvy grow pale and fretful and fail to gain weight The temperature may range from 101° to 105° F The joints may be swollen and extremely tender There is usually hemorrhagic gingivitis, and the teeth, if present, reveal faulty nutrition Pyuria, pyelitis, and hematuria are common Rachitic manifestations, especially "beading" at the costochondral junctions, are often noted

Roentgen Observations —The characteristic changes in the bones are seen just behind the diaphyseal line in the so-called Trommer's zone—an area of decalcification presenting the appearance of a second epiphyseal line The epiphyseal line and the epiphysis are usually normal, but in a well-developed case of scurvy, according to Pelkan, the line is finely irregular, broadened, and well calcified, with a small spur at the lateral edge Occasionally the epiphysis is separated and dislocated A peculiar double-contoured appearance of the post-scorbutic state persists for years

The shaft may show thickening on the convex side The periosteum is stripped up by hemorrhage, and the hematoma may undergo calcification In the well-developed case, Pelkan found a very thin cortex, often merely a white line, a glass-like transparency of the shaft, without trabeculations as in normal bone or in rickets, and a broad, finely irregular white edge on the epiphyseal center of ossification of the long bones There is no change in the medulla except in the region of Trommer's zone In severe scurvy there is atrophy from disuse because of great pain which is exaggerated by the slightest movement

As healing takes place, the hematoma gradually becomes organized and calcification sets in Neither the elevated periosteum nor the hemorrhage may be discoverable in the roentgenogram until healing begins and calcium is deposited Calcification of the detached periosteum or the hematoma indicates healing

Diagnosis —Scurvy must be differentiated from acute osteomyelitis, rickets, fracture, and poliomyelitis

Prognosis —In the earlier stages of the disease, the prognosis is good Great danger lies in the fact that children with this nutritional disturbance are markedly susceptible to infection

Treatment —The prophylaxis consists in giving infants fresh fruit juices and fresh vegetable juices very early Fresh meat also prevents scurvy The antiscorbutic vitamin has been isolated in pure form, and its exact chemical composition has been established Orange, lemon, and tomato juices are specific cures Cabbage is valuable

an actual calcium starvation. Although characterized by osteoporosis, it has to be distinguished from hyperparathyroidism, pseudo-osteomalacia malignum and hyperthyroidism.

The fundamental process according to Hodges and Ledoux is probably identical with rickets of children where growth plays an important rôle but the unusual calcium demands of pregnancy or lactation are absent, and with senile or famine osteoporosis where diet deficiency is the sole factor. Much less close is the relationship to the osteoporosis that follows primary parathyroid dysfunction, to Paget's disease or to osteitis fibrosa cystica.

It is found chiefly in famine districts or where peculiar religious or social prohibitions keep women indoors, away from light.

Osteomalacia may occur at all ages, but the larger number of cases occur in women during the child-bearing period. However, women who have never been pregnant may suffer from it, and occasionally the disorder attacks men. When elderly people are affected the term "senile osteomalacia" is used.

The symptoms are chiefly rheumatic pains, the roentgenographic findings are softening, decalcification, deformities of the bone, and in some cases fractures. The pathological changes are decalcification of the bony framework and reversion of the resulting organic matrix and medulla to fibrocellular connective tissue. This tissue may either degenerate, and break up into débris and fat or may develop into incompletely calcified cancellous bone. The reparative change is met with in those fractures in osteomalacic bones that unite by callus which is no doubt induced by the stimulus of the injury. Bending and fractures are the two principal deformities.

The treatment is supportive plus an antirachitic diet including vitamins, especially vitamin D, and heliotherapy. Cod-liver oil, phosphorus and viosterol are of value.

SCURVY

Scurvy is a disease due to vitamin C deficiency and is manifested by subcutaneous, submucous, and subperiosteal hemorrhages as well as generalized symptoms. It occurs in children between the sixth and tenth months of life. As the result of improved prophylaxis, it has become uncommon in children. It is rare in adults.

Scurvy develops as the result of a lack of fresh foods containing vitamin C. From studies of dentin, bone matrix, and the collagen of connective tissues in connection with growth and repair Wolbach and Howe have gained the impression that the supporting tissues are unable to produce and maintain intercellular substances, and that the localized hemorrhages are due to lack of cement substances in the blood-

vessels Capillary fragility leading to the appearance of petechiæ is one of the earliest manifestations of the effects of a scurvy-producing diet In scurvy there is loosening of the attachments of ligaments and tendons

Symptoms —Babies suffering from scurvy grow pale and fretful and fail to gain weight The temperature may range from 101° to 105° F The joints may be swollen and extremely tender There is usually hemorrhagic gingivitis, and the teeth, if present, reveal faulty nutrition Pyuria, pyelitis, and hematuria are common Rachitic manifestations, especially "beading" at the costochondral junctions, are often noted

Roentgen Observations —The characteristic changes in the bones are seen just behind the diaphyseal line in the so-called Trommer's zone—an area of decalcification presenting the appearance of a second epiphyseal line The epiphyseal line and the epiphysis are usually normal, but in a well-developed case of scurvy, according to Pelkan, the line is finely irregular, broadened, and well calcified, with a small spur at the lateral edge Occasionally the epiphysis is separated and dislocated A peculiar double-contoured appearance of the post-scorbutic state persists for years

The shaft may show thickening on the convex side The periosteum is stripped up by hemorrhage, and the hematoma may undergo calcification In the well-developed case, Pelkan found a very thin cortex, often merely a white line, a glass-like transparency of the shaft, without trabeculations as in normal bone or in rickets, and a broad, finely irregular white edge on the epiphyseal center of ossification of the long bones There is no change in the medulla except in the region of Trommer's zone In severe scurvy there is atrophy from disuse because of great pain which is exaggerated by the slightest movement

As healing takes place, the hematoma gradually becomes organized and calcification sets in Neither the elevated periosteum nor the hemorrhage may be discoverable in the roentgenogram until healing begins and calcium is deposited Calcification of the detached periosteum or the hematoma indicates healing

Diagnosis —Scurvy must be differentiated from acute osteomyelitis, rickets, fracture, and poliomyelitis

Prognosis —In the earlier stages of the disease, the prognosis is good Great danger lies in the fact that children with this nutritional disturbance are markedly susceptible to infection

Treatment —The prophylaxis consists in giving infants fresh fruit juices and fresh vegetable juices very early Fresh meat also prevents scurvy The antiscorbutic vitamin has been isolated in pure form, and its exact chemical composition has been established Orange, lemon and tomato juices are specific cures Cabbage is valuable

If milk is heated in a vacuum or subjected to but little air in the course of sterilization, almost all of its antiscorbutic vitamin is preserved. Citrus fruits can be desiccated without serious deterioration if suitable precautions are taken. Tomatoes lose little of their value in the canning process.

From concentrated lemon juice, a crystalline material has been obtained which exerts a powerful antiscorbutic action. An equally potent crystalline substance has been prepared from the cortex of the suprarenal glands. This substance is called "ascorbic acid."

In 1795, every vessel in the British navy was required to carry a supply of lime juice as a protection against scurvy, which broke out regularly among the sailors on long sea voyages.

Adult Scurvy.—In the causation of scurvy in adults, ready-to-serve foods, dietary fads, and chronic alcoholism play a rôle. In Shattuck's 17 adult cases of scurvy, the cardinal diagnostic points were extensive painful ecchymoses involving the legs, and a history pointing to a dietary deficiency. In the differential diagnosis it is necessary to consider hemophilia, acute infectious diseases, arthritis, and the purpuras and other circulatory or vascular disturbances.

Vitamin B Deficiency.—In all the peripheral neuropathies there is an increasing tendency to prescribe vitamin B_1 and the vitamin B complex. It is very significant that many of these lesions respond to a remarkable degree and with unusual speed to oral and intravenous vitamin B_1 therapy.

ENDOCRINE DISTURBANCES AFFECTING THE FOOT AND ANKLE

Endocrine disturbances may cause trouble that is reflected in the feet. The chief conditions are obesity; thyroid disturbances, especially myxedema; and pituitary gland disturbances.

The foot of the child with the Fröhlich syndrome is flat. Many feet are ruined or have their function jeopardized for many years because during this period, these children are allowed to go in oxfords, some of which do not even fit. These children should be in high-laced shoes while their general glandular and epiphyseal treatment is being carried out.

DIABETES

There are over 700,000 diabetics in the United States today and each should consider himself destined to have some foot trouble. Physicians and surgeons have studied such patients very carefully and have learned their problems and the methods of determining the circulation of their feet and legs and have come to observe special precautions in performing surgical operations on them.

Of the approximately 1,000,000 diabetics or potential diabetics in the United States, a large number are receiving localized foot treatment

It is essential for the diabetic to burn sugar, therefore exercise as a method of improved circulation is highly necessary Such exercise necessitates increased foot activity The majority of diabetics are overweight, a condition which often causes stress and strain on the arches of the foot For this reason, shoes must fit properly

The physician impresses upon the diabetic the fact that he must be meticulously careful in the hygiene of his feet, and should have regular local foot care The physician warns the patient never to touch his own feet other than what is necessary for proper hygiene

In no other disease is such cooperation necessary between the patient, the physician and the chiropodist as in diabetes

According to Ober too little attention is paid by physicians to corns, callosities, and other pressure areas in the diabetic Joslin, emphasizes the fact that the prophylactic treatment of gangrene is seldom taught, but it is important Root found the average weight of 22 patients, who had gangrene to be 201 pounds One diabetic in 5 after the age of seventy acquires gangrene, and for eighteen years, in Boston, 1 diabetic in 5 died with it as a contributory cause All the measures which are advised when gangrene appears should have been adopted in a modified and appropriate form years before its appearance Muryama and Sakaguchi did not have a single case of death from gangrene in their 40 fatal diabetics, despite the known marked arteriosclerosis of Japanese diabetics The Japanese wear thick socks and sandals which do not compress the feet

Fever is the most valuable evidence of the severity and seriousness of the infection

Solley's analysis of the histories as to the type of injury which led to amputation, revealed the following

1 Shoe pressure on corn, 10 cases
2 Walking on plantar callus, 4
3 Patient cut corn, 4
4 Soft corn removed by chiropodist, 1
5 Infection and gangrene, cause unknown
6 Dry gangrene, cause unknown, 3
7 Accidental injuries (no one to blame)—
    (a) "Injury to foot"
    (b) Dropped pan on foot
    (c) Foot was stepped upon by someone
    (d) Burned toe soaking feet in hot water
    (e) Accidentally scratched dorsum of foot
    (f) Went to sleep with electric pad on foot

He emphasized the importance of specialization in the surgical care

of the diabetic lower extremity. Equally important, is the closest coöperation between the physician and surgeon. Hospital reports, show striking reduction in mortality when such organization has been adopted, and prove the advantages to be gained by any institution able and willing to so specialize. It is in the hope of stimulating the desire for better surgical care of the diabetic lower extremity in all hospitals, that the analysis of these cases was undertaken.

We must educate (1) the physician; (2) lay people; and (3) chiropodists.

10 Admonitions for Diabetics

1. Never wear any but white hosiery.
2. Buy them large and shrink them until they will not shrink any more—then they must (*a*) be the correct size; (*b*) have no wrinkles or reduplications.

The Most Important Admonitions to a Diabetic:

1. Keep your body clean
2. Keep your soul clean
3. Keep your feet clean
4. Keep your skin supple, especially the toes
5. Your shoes must be absolutely of correct size and shape—and have no wrinkles or reduplications.

The older person with diabetes is prone to sclerosis of the arteries and subsequent damage to the foot which is in no way different from arteriosclerosis obliterans. In the diabetic patient the conditions are apt to be more serious.

Heat used with caution and applied usually to adjacent areas rather than to the affected leg and foot is useful. It may be obtained by hot sitz baths, short wave diathermy to the pelvic region or the application of heat to an uninvolved leg. Heat over 94° F. may be harmful to an affected leg.

The majority of foot disturbances and complications occurring in diabetic people are due to: (1) inefficient foot prophylaxis, (2) static foot defects causing strain and injury, (3) self-pedicure or ill-advised chiropody, (4) improper or poorly fitting footgear, (5) foot deformities such as corns, calluses, hammertoes, bunions and spurs.

Anyone caring for diabetics should include a thorough foot examination and should correct, at an early date, any abnormal condition found. Self-pedicure should be warned against, and podiatrists should be made acquainted with the problems presented in the care of diabetic patients with foot complaints.

Early recognition of circulatory changes and an intelligent attempt

to improve the circulation may ward off complications until a sufficient substitute circulation has been established

Allen stated that from 3 to 5 per cent of all diabetics have gangrene Ten per cent of the deaths of diabetics are due to gangrene The causes of gangrene are impairment of the circulation due to arteriosclerosis, trauma and infection After the introduction of insulin the *mortality dropped from between 25 and 50 per cent to 10 per cent*

The skin of the diabetic is vulnerable because instead of being filled with glycogen, it contains sugar When diabetes is untreated, lesions of the skin heal slowly, but when diabetes is under control, they heal well Insulin protects the skin because of its power to transform sugar, a soluble carbohydrate derived from the food, into glycogen or animal starch, an insoluble carbohydrate, and store it in the skin The recognition and control of even mild diabetes is a safeguard against infection The healing of chronic ulcers or indolent wounds may be stimulated by the direct application of insulin to the wound

Insulin also stores glycogen in the walls of the arteries, thereby reducing the incidence of arteriosclerosis which attacks diabetics prematurely and is responsible for one-half of the deaths from the disease On the other hand, there has been an alarming increase in the frequency of arteriosclerotic disease because of the prolongation of life resulting from insulin treatment Black states that insulin has doubled or trebled the average expectancy of life of diabetics Arteriosclerosis obliterans plus diabetes is a serious condition requiring immediate intensive treatment Every diabetic should have 1 multi-vitamin tablet daily In addition he should have 100 mg of thiamine hydrochloride daily preferably by hypo in cases with neuritis

According to Samuels, prevention of diabetic gangrene is possible if the diagnosis of circulatory deficiency is made in the incipient stages and proper treatment is instituted at once Conservative treatment is often successful providing meticulous care is given the local condition, with due regard for asepsis and antisepsis Particular attention should be paid to ringworm infection of the interdigital spaces Uncontrollable infection or massive, non-demarcating gangrene justifies amputation The operation of choice is a simple, circular amputation through the lower third of the thigh, with tight closure of the stump and no drainage

As soon as diabetes is discovered, the patient should be given special instructions with regard to general and local hygiene He must be the most careful citizen in the community Scrupulous cleanliness of the skin is imperative, and injuries and infections must be avoided The diet must be accurately prescribed and meticulously followed Any unusual physical or mental effort may so lower the level of glucose tolerance and the glucose level of the blood that a typical insulin shock

may ensue. The most valuable and least harmful exercise for the diabetic is walking on level surfaces in accurately fitted shoes with no rough areas or hard pressure points. The hosiery must also be fitted meticulously and must be free from irregularities. Sleep for at least eight of the twenty-four hours is imperative. Emotional disturbances are very harmful.

The diabetic is exposed to many hazards daily. The greatest emphasis must be placed upon the care and hygiene of the legs and feet. It must be borne in mind that the function and structure of the blood-vessels of the diabetic are impaired. Anything that lowers the resistance or breaks the skin will permit germs to enter into a vulnerable and fertile field. One of the greatest dangers to a diabetic is a new pair of shoes. New shoes should be broken in gradually. It is better for a diabetic to have the shoemaker or the shoe salesman break in the shoes than to break them in himself as the breaking-in process may cause irritation, with resulting ulcers or cracks in skin. For the first ten days new shoes should be worn no longer than one-half hour at a time. Hosiery demands the most meticulous attention because all seams, darns, knots, and loose threads will cause pressure with damage to skin A diabetic person should have his corns, calluses, and other foot defects treated by an orthopædic surgeon, or a competent chiropodist. In the use of hot-water bottles and electric heating pads, great care is necessary with regard to the degree of heat and the length of time of application, as a very slight hyperemia or burn may be followed by serious infection and the development of fatal gangrene.

In Joslin's Clinic, diabetics are given the following instructions:

"**Hygiene of the Feet.**—1. Wash the feet daily with soap and water. Dry them thoroughly, especially between the toes, using a 'blotting' pressure rather than vigorous rubbing.

"2. When they are thoroughly dry, rub them with lanolin as often as necessary to keep the skin soft and free from scales and dryness, but never render the feet tender. If the feet become too soft, rub them once a day with alcohol.

"3. If the nails are brittle and dry, soften them by soaking the feet in warm water one-half hour each night and apply lanolin generously under and about nails and bandage loosely. Clean the nails with orange-wood sticks. Cut the nails only in a good light and after a bath, when the feet are very clean. Cut the nails straight across to avoid injury to the toes. If you go to a chiropodist, tell him you have diabetes.

"4. If the toes overlap or are close together, separate them with lamb's wool. If the joints are large or the toes are cramped-up, wear shoes of vici kid leather without toe boxes.

"5. If you are over sixty years old, rest at intervals during the day with your shoes off.

"6 *Do not* wear bedroom slippers when you ought to wear shoes Slippers do not give proper support

"7 Wear shoes of soft leather which fit and are not tight (neither *narrow nor short*) Wear new shoes one-half hour only on the first day and increase one hour daily Do not step on the floor with the bare feet

"8 Use bed socks instead of hot-water bottles, bags, or electric heaters

"9 Every Sunday morning ask someone to examine your feet

"10 After fifty years one hears less well, sees less well, and the sense of feeling is diminished Remember this and be cautious about the feet

"**Treatment of Corns and Callosities** —1 Wear shoes which fit and cause no pressure

"2 Soak the feet in warm, not hot, 'soapy' water Rub off with gauze, or file off the dead skin on or about a callus or corn Do not tear it off Do not cut corns or callosities Do not try to remove corns or calluses with patent or other medicines An emery board can be used to advantage in some cases

"3 Prevent calluses under the ball of the foot

(*a*) By exercises such as curling and stretching of the toes twenty times a day

(*b*) By finishing each step on the toes and not on the ball of the foot

"**Aids in the Treatment of Imperfect Circulation** —Cold feet 1 Exercises Bend the foot down and up as far as it will go six times Describe a circle to the left with the foot six times and then to the right Repeat morning, noon and night

"2 Massage with lanolin or cocoa butter

"3 Do not wear circular garters Do not sit with the knees crossed

"4 *If you have had gangrene or have been threatened with it, do* not remain on your feet more than two hours in the morning, two hours in the afternoon and two hours in the evening"

Treatment of Abrasions of the Skin

1 Proper first-aid treatment is of the utmost importance even in apparently minor injuries Consult your physician immediately
2 Avoid strong irritating antiseptics
3 As soon as possible after injury certain surgeons recommend the application of sterile gauze saturated with medicated alcohol or hexylresorcinol (S T 37) Keep wet for not more than thirty minutes by adding more of the antiseptic solution Sterile gauze in sealed packets may be purchased at drug stores
4 Elevate, and as much as possible until recovery, avoid using the foot
5 Consult your doctor for any redness, pain, swelling, or other evidence of inflammation

may e ... that at least one-third of all diabet ... time during the course of rough ... surgery are of advanced age, meti ... arterio-sclerosis and other eigh ... the surgical risk independently. are ... diabetics from serious complica- ... except in the more urgent cases. ph ... Wilder, and Adams found I ... operative management, the proper ... of anesthetics, and a surgical ... trauma and delay, contribute greatly

... operations are very susceptible ... this complication can be practically elimi- ... betics need both food and liquids before ... carbohydrates by mouth or rectum ... and after operation. Three hours before ... the patient is usually given 150 cc. of ... more or less) of insulin, depending upon the ... Ethylene anesthesia is favored because ... sweating and therefore less loss of water ... anesthesia of other types. Cyclopropane ... also recommended. After the operation, ... given as soon as the patient can take it.

... and persistent vomiting, glucose solution, ... value. During the first week or two, under- ... provided the patient gets his usual quota of ... mild cases, synthalin, a guanidine derivative, may ... few units of insulin.

... that surgery on diabetics depends upon ... be sent to the operating room with his diabetes ... state cannot be judged from the blood sugar ... important chemical sign contraindicating operation ... indicates that the diabetes i ... out of control. ... operation in cases of une ... iabetes differs ... balancing in only one re ... patient must ... amount of food from the ... ast 1,800 cal ... 150 to 200 gm. of carbohydr ... of insul ... il ketonuria is completel ... nd glycosu ... timum. Protamine zi ... uld not ... is available for obse ... nder local anesth ... th ... special measu ... ler anesthe

anesthetic requires special preparation. The meal and insulin just before the operation should be omitted, but two or three hours before the operation, 50 gm. of sugar in lemonade should be given, and as the patient is put on the cart, 35 units of insulin should be administered subcutaneously. If the patient has been on protamine insulin and the operation is to be performed in the morning, the same preparation should be given without breakfast or protamine insulin. If the operation is to be performed in the afternoon, he should receive the usual dose of protamine insulin and luncheon should be omitted, but three hours before the operation he should be given 30 gm. of sugar and 10 units of insulin as he goes to the operating room. Ether produces vomiting, which may complicate treatment by interfering with the intake of food. Chloroform is to be condemned. Postoperative dehydration and diabetic ketosis must be prevented, the former by the administration of dextrose saline solution and water, the latter by the administration of insulin. After the operation a patient who can take food by mouth should be given sweet lemonade. Every specimen of urine should be tested, if there are no ketones, with Benedict's solution. If the precipitate is red, the patient should have 20 units of insulin, if yellow, 50, if green, 10. If there is no precipitate, no insulin should be given. If ketonuria is present, more carbohydrate should be given and 25 units of insulin for each 50 gm. of sugar. If the patient is unable to take sugar by mouth during the first twelve hours, he should have insulin according to the color schedule. Ketosis should be combated by the intravenous administration of dextrose and saline solution, 1 pint an hour for two or three hours, and for every 50 gm. of dextrose, from 30 to 50 units of insulin should be given according to the severity of the ketosis. If, after twelve hours, it is still impossible to give dextrose by mouth, more dextrose and saline solution should be injected intravenously with 25 units of insulin.

O'Kane and Williams emphasize that in the handling of diabetic limb disease the following three requirements should always be kept in mind: (1) the avoidance of infection, (2) preservation of the circulation and (3) the avoidance of trauma. They state that these requirements are met by simplicity and care in the operative technique.

Amputations of Lower Extremities of Diabetics.—Amputation on a diabetic patient should be done under spinal anesthesia induced with novocain. In the preparation of the skin, the field should be thoroughly scrubbed with soap and water, then cleansed with alcohol and ether, and painted with 5 per cent neutral acriflavin in 50 per cent alcohol as advised by Tinker and Sutton. After this has been done, a sterile dressing should be applied. At the time of operation, the field should again be painted with the acriflavine preparation. Before the limbs are draped, the field should be completely dry. The

use of tincture of iodine should be reduced to a minimum. As a rule, no tourniquet should be used. Drainage of the stump is rarely indicated.

In a report covering a five-year period at St. Luke's Hospital in New York City, Solley stated that the indications for amputations depend upon two factors:

1. Circulation.
2. Infection.

Oscillometric and dermothermic readings are not routinely used. He believes these facilities are entirely unnecessary in arriving at an accurate and reliable decision as to the indication for amputation. Experienced and intelligent use of the time-proved methods of inspection and palpation are sufficient. The circulation is considered "adequate" if the patient shows:

1. A warm foot with or without a palpable dorsalis pedis pulsation.
2. Little or no pain on bed rest for twenty-four to forty-eight hours with adequate diabetic treatment.

CHAPTER XXIX

GANGRENE OF THE FOOT AND ANKLE

The basic facts have not changed It is a treacherous condition It costs lives and limbs Immediate good surgery is the determining factor Conservative treatment such as x-ray, and chemotherapy are not dependable Chemotherapy is a most valuable adjunct Blood transfusions are most valuable aids The important decision that confronts the surgeon is to operate or not to operate and how much to do There is great danger of cutting across infected lymphatic channels

Gas Gangrene —Experience has proved the value of immediate good surgery, wide excision of damaged tissues, chemotherapy and transfusions given synchronously with the surgery

When the arterial circulation in the extremity becomes insufficient for life of the part, the severe pain characteristic of dying tissue sets in At the onset, the pain is felt at the point where the gangrene is about to appear As the gangrene develops, the pain disappears from the dead area, follows the dying tissue, and continues at its greatest severity until the line of demarcation is definitely established

After the line of demarcation has been established, the process of self-amputation of the dead tissue sets in and represents the subsiding phase of gangrene

Gangrene may be dry or moist Among its causes are trauma, infections, embolism, circulatory disturbances and neoplasms Trauma includes blows, cold, heat, and chemicals Trauma crushes tissues Circulatory disturbances resulting in ischemia may be due to embolism, thrombosis, aneurysm, ligation, or sclerosis The sympathetic nervous system exerts an important effect upon the caliber of the blood-vessels The pathological changes may involve the blood-vessels, nerves, and other tissues The diagnosis is based upon the history, the appearance and temperature of the tissues and the absence of arterial pulsation in the involved member after elevation and depression Roentgenray findings are negative unless bone is involved The prognosis depends upon the blood and nerve supply of the tissues and the presence or absence of secondary infection

The treatment includes prophylaxis, protection, warmth, and elevation Amputation should be delayed until a line of demarcation appears unless its delay will jeopardize the patient's life The preoperative considerations include asepsis and transfusion Transfusion may be necessary during the operation Postoperatively, transfusion, hypodermoclysis, and other measures are employed to combat or prevent shock

Hemolytic streptococcus gangrene usually appears on the extremities. It is characterized clinically by rapid development, profound prostration and a dusky hue of the skin with or without blisters or bullæ. The margin is not raised and usually not clearly defined. The lesion differs from ordinary streptococcus cellulitis in the greater rapidity of its development; the rarity of lymphangitis and lymphadenitis, and the early appearance of the dusky hue of the skin or blisters. In sharp contradistinction to the treatment of other streptococcus infections, incisions should be made as soon as the condition is diagnosed.

Meleney advises that the incisions be made from the gangrenous area proximally and distally as far as the subcutaneous necrosis extends, but no farther. He finds that it is not necessary, and may even be harmful to cut into the zone of cellulitis. The gangrenous skin should be excised as soon as the line of demarcation has developed to the point at which the dead skin can be removed without causing much hemorrhage. After the operation the part should be placed in water at a temperature of from 104° to 107.6° F. (40° to 42° C.) for two hours out of three in the daytime and for one hour out of three at night. At the end of twenty-four hours the cellulitis is usually greatly diminished, and at the end of forty-eight hours it may have entirely disappeared. Dakin's solution should be applied by Carrel tubes or by compresses soaked in the solution and changed every two hours. In most cases the infection is superficial and can be controlled by superficial incision. When there is bone involvement as a result of the initial injury early amputation is advisable.

Kramer offers the following points of differential diagnosis between diabetic and arteriosclerotic gangrene:

	Arteriosclerotic.	Diabetic.
Age	Senile, usually in 7th decade	May occur in 5th or [illegible] decade
Pain	Usually severe even with small area of gangrene	Varies; may be absent or mild in early stages
Infection	Not present	Nearly always present; may have considerable sloughing
Type of gangrene	Dry	May be dry [illegible]
Line of demarcation	Present	[illegible]
Extension	Along lines of arterial supply	May extend laterally [illegible]
Pulse	Absent or markedly diminished	May be present [illegible]
Roentgen-ray	Calcification of walls of arteries	Arteries may show no detectable path[illegible]
Pathologic features	Thickening of the walls with calcific deposits	Atheromatous changes [illegible]
Microscopic appearance of vessels	Medial form of sclerosis	Intimal form of sclerosis

Massive anaphylactic gangrene is a form of reaction occurring in sensitized subjects which dates back to the Arthus phenomenon It follows the use of any type of serum, such as diphtheria or meningococcus serum, and occurs commonly in the buttocks

Infection is a serious complication of gangrene In diabetic cases it is present almost invariably Diabetic gangrene is the end-product of three main influences the metabolic disturbances and their effect upon the vessels and tissues, changes in the arteries with resulting deficiency of the blood supply to the parts, and infection

In the last few years, thanks to insulin and improved medical care, the hazards of minor and major surgery on diabetics have been remarkably reduced

Gangrene of the foot is of three main types trophic ulcers, arteriosclerotic gangrene and thrombo-angiitis obliterans Wolf considers heat treatment to be contraindicated in all cases with cyanosis He recommends gentle massage radiating from the ulcer, three or four times a day, about fifteen minutes each time

Perforating ulcer of the foot may be caused by circulatory (chiefly arterial), neurogenic, or neurotrophic lesions The sites of this lesion are the weight-bearing areas of the foot, namely, the plantar surface, the metatarso-phalangeal joints especially over the borders of the first and fifth toes and the heel The lesion may be bilateral Buerger advances four etiological theories, *viz*, a mechanical, a vascular, a neurogenic, and an arthropathic or osteopathic theory The vascular cause is occlusion of the arteries resulting from arteriosclerosis, thrombosis, or thrombo-angiitis obliterans The neurogenic factors may be peripheral or central in origin The peripheral nerve lesions follow freezing, burns wounds, contusions, and other injuries Occasionally, injuries of the posterior sacral roots or injuries to the sciatic nerve and tumors involving the larger nerves are factors Leprosy, alcoholism, syphilis, and arteriosclerosis may be responsible Lesions of the central nervous system include tabes dorsalis, fractures of the vertebræ with injury to the spinal cord, tumors of the spinal cord, spina bifida, and syringomyelia The lesion may be associated with progressive paralysis, progressive muscular atrophy, amyotrophic lateral sclerosis, or spastic paraplegia Diabetes may cause a painful perforating ulcer Various forms of treatment have been advised, including care of the local as well as the underlying conditions Nerve stretching has been recommended very highly Perivascular sympathectomy and sympathetic ramisection have been recommended by some, notably Leriche

In diabetic gangrene, which affects the toes more frequently than any other part, early careful surgery may be very effective The hygiene of the feet of the diabetic person is very important In

Hemolytic streptococcus gangrene usually appears on the extremities. It is characterized clinically by rapid development, profound prostration and a dusky hue of the skin with or without blisters or bullæ. The margin is not raised and usually not clearly defined. The lesion differs from ordinary streptococcus cellulitis in the greater rapidity of its development; the rarity of lymphangitis and lymphadenitis, and the early appearance of the dusky hue of the skin or blisters. In sharp contradistinction to the treatment of other streptococcus infections, incisions should be made as soon as the condition is diagnosed.

Meleney advises that the incisions be made from the gangrenous area proximally and distally as far as the subcutaneous necrosis extends, but no farther. He finds that it is not necessary, and may even be harmful to cut into the zone of cellulitis. The gangrenous skin should be excised as soon as the line of demarcation has developed to the point at which the dead skin can be removed without causing much hemorrhage. After the operation the part should be placed in water at a temperature of from 104° to 107.6° F. (40° to 42° C.) for two hours out of three in the daytime and for one hour out of three at night. At the end of twenty-four hours the cellulitis is usually greatly diminished, and at the end of forty-eight hours it may have entirely disappeared. Dakin's solution should be applied by Carrel tubes or by compresses soaked in the solution and changed every two hours. In most cases the infection is superficial and can be controlled by superficial incision. When there is bone involvement as a result of the initial injury early amputation is advisable.

Kramer offers the following points of differential diagnosis between diabetic and arteriosclerotic gangrene:

	Arteriosclerotic.	Diabetic.
Age	Senile, usually in 7th decade	May occur in 5th or 6th decade
Pain	Usually severe even with small area of gangrene	Varies; may be absent or mild in early stages
Infection	Not present	Nearly always present; may have considerable sloughing
Type of gangrene .	Dry	May be dry [illegible]
Line of demarcation .	Present	[illegible]
Extension .	Along lines of arterial supply	May extend laterally [illegible]
Pulse .	Absent or markedly diminished	May be present [illegible]
Roentgen ray . .	Calcification of walls of arteries	Arteries may show [illegible]
Pathologic findings . . .	Thickening of the walls with calcific deposits	Atheromatous changes [illegible]
Microscopic appearance of vessels	Medial form of sclerosis	Intimal form of sclerosis [illegible]

Massive anaphylactic gangrene is a form of reaction occurring in sensitized subjects which dates back to the Arthus phenomenon. It follows the use of any type of serum, such as diphtheria or meningococcus serum, and occurs commonly in the buttocks.

Infection is a serious complication of gangrene. In diabetic cases it is present almost invariably. Diabetic gangrene is the end-product of three main influences: the metabolic disturbances and their effect upon the vessels and tissues, changes in the arteries with resulting deficiency of the blood supply to the parts, and infection.

In the last few years, thanks to insulin and improved medical care, the hazards of minor and major surgery on diabetics have been remarkably reduced.

Gangrene of the foot is of three main types: trophic ulcers, arteriosclerotic gangrene and thrombo-angiitis obliterans. Wolf considers heat treatment to be contraindicated in all cases with cyanosis. He recommends gentle massage radiating from the ulcer, three or four times a day, about fifteen minutes each time.

Perforating ulcer of the foot may be caused by circulatory (chiefly arterial), neurogenic, or neurotrophic lesions. The sites of this lesion are the weight-bearing areas of the foot, namely, the plantar surface, the metatarso-phalangeal joints, especially over the borders of the first and fifth toes and the heel. The lesion may be bilateral. Buerger advances four etiological theories, viz., a mechanical, a vascular, a neurogenic, and an arthropathic or osteopathic theory. The vascular cause is occlusion of the arteries resulting from arteriosclerosis, thrombosis, or thrombo-angiitis obliterans. The neurogenic factors may be peripheral or central in origin. The peripheral nerve lesions follow freezing, burns, wounds, contusions, and other injuries. Occasionally, injuries of the posterior sacral roots or injuries to the sciatic nerve and tumors involving the larger nerves are factors. Leprosy, alcoholism, syphilis, and arteriosclerosis may be responsible. Lesions of the central nervous system include tabes dorsalis, fractures of the vertebrae with injury to the spinal cord, tumors of the spinal cord, spina bifida, and syringomyelia. The lesion may be associated with progressive paralysis, progressive muscular atrophy, amyotrophic lateral sclerosis, or spastic paraplegia. Diabetes may cause a painful perforating ulcer. Various forms of treatment have been advised, including care of the local as well as the underlying conditions. Nerve stretching has been recommended very highly. Perivascular sympathectomy and sympathetic ramisection have been recommended by some, notably Leriche.

In diabetic gangrene, which affects the toes more frequently than any other part, early careful surgery may be very effective. The hygiene of the feet of the diabetic person is very important. In

operating upon a diabetic patient great care is necessary. The reader is referred to the writings of McKittrick and Root and Apfelbach.

Amputation of the foot or its parts requires considerable skill and judgment. It is performed chiefly for gangrene due to diabetes, arteriosclerosis, thrombo-angiitis obliterans, embolism, infection, or injury.

AMPUTATIONS OF THE FOOT AND ANKLE

The most important lesions necessitating amputation are: (1) extensive infection that endangers the life of the person or the limb; (2) gangrene due to thrombo-angiitis obliterans, diabetes, arteriosclerosis, senility, or Raynaud's disease; (3) compound fracture with infection; (4) extensive laceration or crushing of muscles, nerves, and blood-vessels; (5) avulsion of part or all of an extremity; (6) extensive comminution of bone, such as in shrapnel and other gunshot wounds; (7) embolism or arteriovenous aneurysms of important blood-vessels; (8) tumors of bone, such as osteogenic sarcoma or fibrosarcoma; (9) the Charcot joint; (10) severe uncorrectable deformities; and (11) extensive or uncontrollable osteomyelitis. Robertson believes that amputation is better than some of the painful flat-feet that are seen.

The chief relative contraindications to amputations are extreme shock and advanced anemia and hemophilia.

The types of amputation are the Lisfranc, Chopart, Syme, and Gritti-Stokes.

The purpose of an amputation is to save life, decrease the duration and degree of invalidism, and rid the patient of useless parts. The common indications for such operations are compound fractures, gangrene, diabetes, tuberculosis, circulatory disturbances, injuries, osteomyelitis, tumors, and permanent deformities.

The indications for amputation can be divided into congenital, traumatic, infectious, circulatory, and neoplastic lesions. The congenital defects are supernumerary toes, defective members, partial absence of members, and deformities. Except in time of war, the average surgeon performs an amputation comparatively rarely.

The requirements of a good stump are mobility, power, leverage, and freedom from pain. For mobility and power the muscles and skin must be free from adherence to the scar. After the operation care must be taken to restore joint function, muscle strength, normal circulation, and general activity. The surgeon must know where a proper appliance can be obtained and when it should be fitted, and should coöperate with the artificial limb maker.

The principles of amputation prescribe: (1) that a constrictor be used whenever possible; (2) that all vessels be tied securely and the

large vessels doubly ligated, (3) that nerves be amputated as high as possible and their ends be injected with absolute alcohol, (4) that the fibula be cut 1 inch higher than the tibia, (5) that the stump be well padded, and (6) that the stump be used as soon as possible

One must be familiar with the cross-section anatomy of the extremities at all levels, but especially at sites of election for amputations (The *Atlas* of Eycleshymer and Jones and textbooks of anatomy, especially Gray's and Callander's, should be consulted)

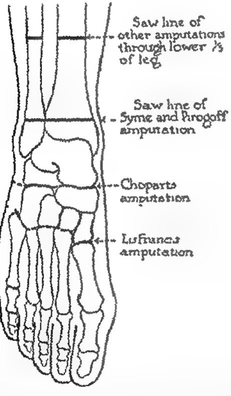


FIG 337 —Sites of amputations accepted by many authorities as giving ideal stumps Considered inferior by Kirk from a functional standpoint except on rare occasions to an amputation through the lower part of the middle third of the leg (Lieut Col N T Kirk M D courtesy of Jour Bone and Joint Surgery)

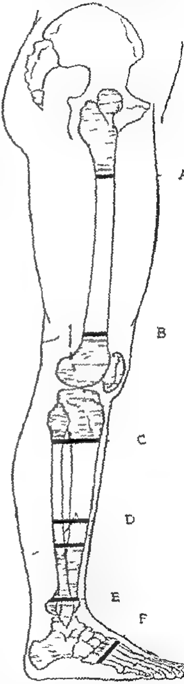


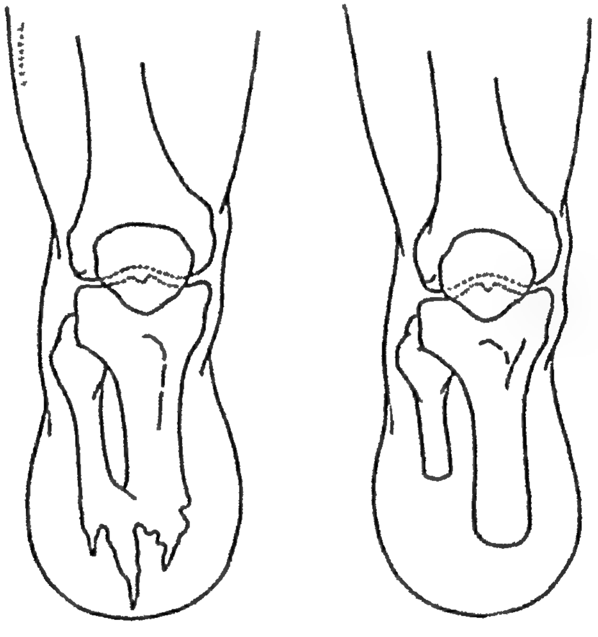
FIG 338 —Sites of election of amputations of lower extremity from standpoint of fitting and wearing artificial limb (The fibula should be shorter than the tibia)

The pre-operative care for amputation includes forced fluids, opiates, and plasma and blood transfusion In cases of diabetes, hypodermolysis and insulin are indicated The pre-operative preparation is

important, especially in the case of diabetics, patients with circulatory disturbances or serious infections, and those in shock.

Because of the development of safe anesthetics and the special training of anesthetists, the most important element at present is dexterity rather than speed. The selection of the site of amputation is of great importance. (The sites of election are indicated in Fig. 338.)

According to Rovenstine the anesthetist may base the choice of anesthetic entirely on the condition of the patient. The more readily controlled and quickly eliminated drugs are preferred. Patients with diabetes or peripheral vascular diseases are safely anesthetized with cyclopropane. For amputation of a leg, spinal anesthesia may be satisfactory. A technic using procain dissolved in spinal fluid and glucose solution is suggested. For emergency operations following trauma, the intravenous use of morphine and scopolamine is of particular value in controlling pain and conserving time.



A B

Fig. 339.—A, Former amputation of lower leg with formation of bony spikes. B, After proper amputation. (Note rounding of ends of bones.)

Amputation performed with a patient in shock makes it necessary for the anesthetist to treat the circulatory depression by position, intravenous fluids, etc., and to aid in the prevention of cerebral anemia by supplying a high oxygen content to the inspired atmosphere.

Hemorrhage is the most important cause of shock. Complete hemostasis reduces the danger of shock and infection. Undue trauma must be avoided.

The meticulous suturing of analogous structures expedites healing of tissues Large nerve trunks should be put under traction before they are injected with alcohol and cut The remaining end should be cut to the shape of a fish tail The blood-vessels, bones, periosteum, muscles, fasciæ, and skin must not be traumatized

Burrows used adrenalin as a clinical test in amputation in cases of circulatory disturbances The absence of blanching when adrenalin is injected into the tissues indicates that there are no active blood-vessels in the area of the injection

Types of Amputations —Emergency amputations are of three varieties—the guillotine amputation, the through-joint resection, and the amputation with flaps left open The last is done only when the sepsis feared is comparatively mild and the length of limb that can be preserved is so short that the joint above can be permanently preserved by no other procedure As emergency amputations are generally necessitated by sepsis, it is essential in such operations to avoid opening up fresh tissues and to establish maximum drainage Ogilvie advises against the use of the guillotine amputation, calling it "one of the mistakes of the early part of the last war" However, some surgeons believe there are some indications for the procedure Undue retraction of the skin can be prevented by extension Verrall has found spraying of the raw surface with dichloramine, superior to other methods of dressing Reamputation must be deferred until all sinuses have been healed for at least three months and there is no edema of the stump

Too early limb-fitting may lead to a chronic periostitis, especially in cases in which sepsis was the indication for the amputation Loss of the cutaneous nerve supply will lead to trophic disturbances and even to ulcer formation An adherent scar should be excised Ulceration may result from circulatory deficiency, trophic disturbances due to nerve division, syphilis, and syringomyelia Bursæ which form over pressure points cause trouble when the prosthesis does not fit Osteomyelitis of the stump calls for surgery Spurs require removal Stiffness in the joints may necessitate reamputation or arthroplasty to permit the use of a prosthesis Neuromata are especially liable to cause trouble when sepsis has been present Circulatory disturbances of nervous origin may be relieved by sympathectomy and ramisection Causalgia and the "phantom limb" are cured by time, occupation, and cordotomy of the anterior horn of the spinal cord

Verrall recommends using a constrictor, clamping or searing the vessels, removing the constrictor, catching the vessels, then re-applying the constrictor and finishing the operation

Lisfranc's amputation is a transmetatarsal disarticulation or disarticulation at the tarsometatarsal joint

Chopart's amputation is a mediotarsal disarticulation, or disarticulation between the astragalus and the os calcis posteriorly, and the scaphoid and cuboid, anteriorly.

Pirogoff's amputation is an amputation at the ankle joint. The heel flap with the posterior portion of the os calcis, is applied to the sawn surface of the tibia and fibula.

Syme's amputation is an amputation at the ankle and through the malleoli, with a heel flap.

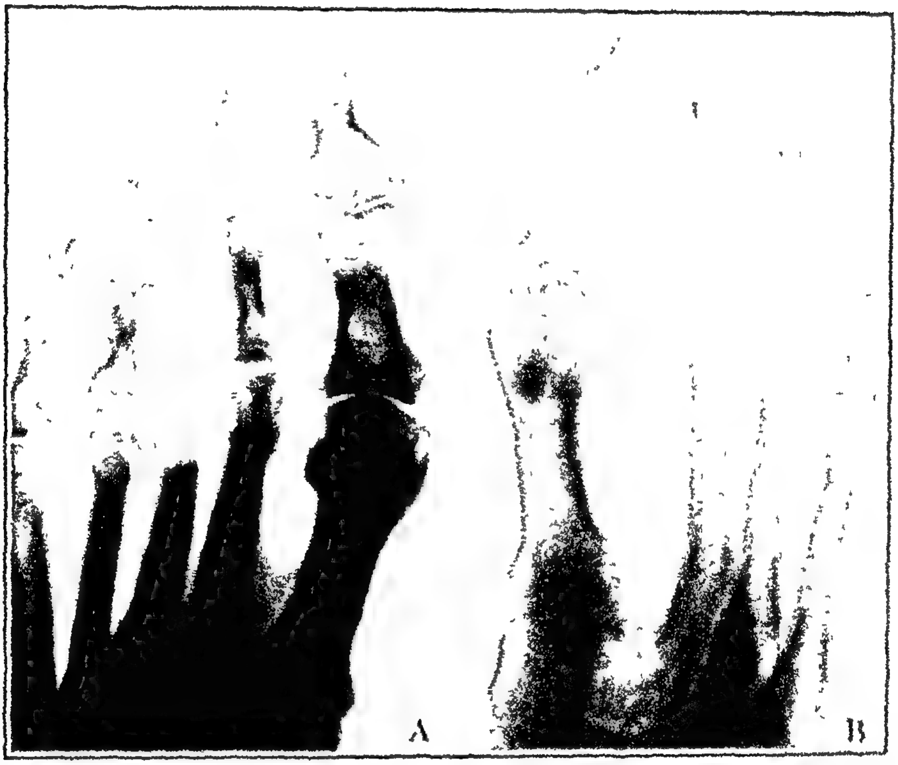


Fig. 340.—*A*, Roentgenogram of a successful amputation of the third toe which was gangrenous from endarteritis obliterans. *B*, Roentgenogram of a foot after removal of the second toe and its metatarsal bone because of osteomyelitis. Perfect functional and anatomical results. (Courtesy of Dr. Robert G. Packard.)

Gritti-Stokes' amputation, an osteoplastic transcondyloid or supracondyloid femoropatellar operation is generally performed just below the medullary canal. The cartilage is removed from the posterior surface of the patella. The upper ligamentum patellæ is not disturbed. The patella is not disturbed. The patella is brought back over the end of the femur, and the lower end or stump of the ligamentum patellæ is sutured to the anterior periosteum of the femur.

Verrall believes that the Lisfranc amputation is satisfactory provided the prosthesis is one in which the loss of the long arch of the foot is replaced by an arch support. (Fig. 357.)

The Chopart amputation is inadvisable for adults, but valuable for

children in whom muscle balance for the gastrocnemius can be obtained by transplantation of the tibialis anticus Guibal and Ginestie express the opinion that the main reason that the amputation of Chopart has fallen into disfavor is because of the relaxation and uselessness of the os calcis as a weight-bearing base They advise teno-suspension to correct this fault and reduce the limp The tendons of the tibialis anterior and flexor hallucis longus are connected through a drill hole near the anterior portion of the os calcis The tendons of the posterior tibial and peroneus longus are similarly connected under the head of the os calcis Thus, a double sling arrangement is utilized to control the motion of the lower leg on the astragalus and os calcis The Syme operation is not as satisfactory as a mid-tarsal amputation

Jepson found metatarsophalangeal amputation satisfactory It is never advisable to leave only one toe A Lisfranc amputation, if the stump is well covered with a plantar flap, may furnish a useful foot In a Pirogoff amputation, the os calcis sometimes fails to unite, becomes displaced, and may become necrotic The partial foot amputation should be avoided as the tendon of Achilles generally contracts pulling the heel up and the amputated surface down Syme's amputation seldom gives satisfaction Whenever it becomes necessary to amputate higher than a disarticulation between the phalanges and metatarsals, the amputation should be performed at the middle of the leg

The most satisfactory location for an amputation below the knee is half way between the knee and the ankle

Le Mesurier advises changing an amputation made below the knee into a Gritti-Stokes amputation in order to convert a lateral into an end-bearing stump

The sooner an artificial limb is worn, the better Patients should be instructed to return to the surgeon rather than to the limb-maker, if any trouble ensues

Lowman emphasizes the fact that, in cases of amputation of a leg, the remaining foot always becomes flat

Experience has proved the value of using provisional appliances in the early treatment of men with amputations

Wilson found that experience gained during the World War I in the treatment of patients with amputations of the lower limb has shown that it is possible to get such patients out of bed without crutches and actively bearing weight on peg-legs or simple forms of artificial limbs at a period two to three weeks after amputation

Early weight-bearing is of great advantage to the patient because (a) It promotes healing of the wound by improving the circulation and in cases with terminal localized osteomyelitis, favors the separation and spontaneous discharge of sequestra (b) It hastens stump shrinkage

and prevents muscle atrophy and the development of joint contractures. (c) It favorably influences the patient's morale. (d) It greatly shortens the period until the permanent artificial limb can be fitted and reduces the need of frequent alterations in the socket.

Provisional apparatus to secure early weight-bearing should be made of simple materials.

The following observations of Kuhns and Wilson are based on an analysis of the end-results of 420 major amputations performed at the Massachusetts General Hospital during the period from 1916 to 1925.

Causes of Amputations

Per cent	Cause	Total	Primary cases	Thigh	Lower leg	Upper arm	Lower arm
26.9	Trauma	113	101	26	37	23	27
10.0	Sepsis	42	35	21	19	0	2
9.5	Endarteritis, thrombo-angiitis, Raynaud's	40	30	19	18	0	3
9.5	Painful amputation stump	40	21	13	27	0	0
8.8	Tuberculosis	37	37	9	19	3	6
8.5	Diabetes (gangrene)	36	28	21	15	0	0
8.5	Arteriosclerosis (gangrene)	36	35	29	7	0	0
7.1	Sarcoma	30	28	21	3	6	0
2.6	Carcinoma	11	11	3	4	1	3
2.3	Thrombosis and embolism	10	9	7	2	1	0
1.9	Gas bacillus infection	8	8	4	1	1	2
0.9	Ununited fracture	4	4	3	1	0	0
0.7	Ruptured brachial plexus	3	3	0	0	3	0
0.7	Spina bifida	3	1	0	3	0	0
0.4	Charcot joint	2	1	1	1	0	0
0.2	Foot deformity (contracture)	1	1	0	1	0	0
0.2	Trophic ulcer	1	1	0	1	0	0
0.2	Tetanus	1	1	1	0	0	0
0.2	Pressure of pelvic tumor	1	1	1	0	0	0
0.2	Gangrene after ligation for popliteal aneurysm	1	1	0	1	0	0
		420	360	179	160	38	[illegible]

Types of Amputation (420 Cases)

	Number	Per cent
Amputation thigh	155	37
Amputation lower leg	152	36.[illegible]
Amputation forearm	[illegible]	12.[illegible]
Amputation upper arm	30	7.0
Gritti-Stokes amputation	13	3.0
Disarticulation hip	9	[illegible]2
Disarticulation shoulder	8	
Syme amputation	6	
Amputation through tarsus	3	
Disarticulation knee	[illegible]	

The reader is referred to an article by Kuhns and Wilson [illegible] ... Med. 1925

If bleeding is carefully arrested, there is no [illegible] drains. When infection is feared, it is better to [illegible]

than to close it with drainage. They advise either tight closure or complete exposure.

Of the patients with amputations of the lower leg, 85 per cent used appliances. Although the functional results of such amputations were usually better than those of amputations of the thigh, a larger propor-

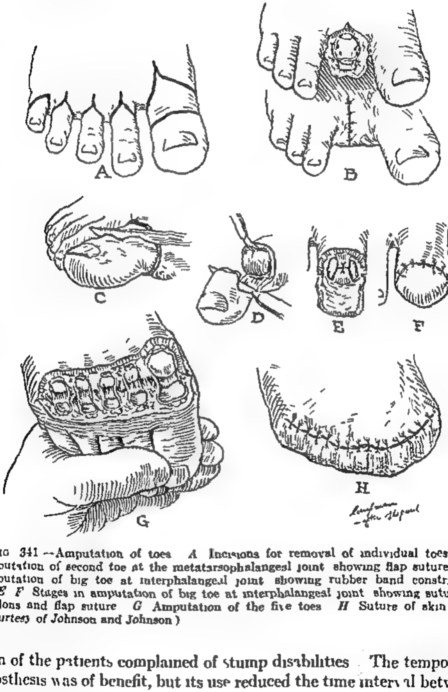


FIG 341.—Amputation of toes. *A* Incisions for removal of individual toes. *B* Amputation of second toe at the metatarsophalangeal joint showing flap suture. *C* Amputation of big toe at interphalangeal joint showing rubber band constrictor. *D E F* Stages in amputation of big toe at interphalangeal joint showing suture of tendons and flap suture. *G* Amputation of the five toes. *H* Suture of skin flap. *(Courtesy of Johnson and Johnson.)*

tion of the patients complained of stump disabilities. The temporary prosthesis was of benefit, but its use reduced the time interval between operation and delivery of the permanent limb less than in the case of amputations of the thigh.

The results of the Syme amputation were satisfactory in 5 of 6

and prevents muscle atrophy and the development of joint contractures. (c) It favorably influences the patient's morale. (d) It greatly shortens the period until the permanent artificial limb can be fitted and reduces the need of frequent alterations in the socket.

Provisional apparatus to secure early weight-bearing should be made of simple materials.

The following *observations of* Kuhns *and* Wilson are based on an analysis of the end-results of 420 major amputations performed at the Massachusetts General Hospital during the period from 1916 to 1926:

Causes of Amputations

Per cent	Cause	Total	Primary cases	Thigh	Lower leg	Upper arm	Fore arm
26.9	Trauma	113	104	26	37	23	27
10.0	Sepsis	42	35	21	19	0	2
9.5	Endarteritis, thrombo-angiitis, Raynaud's	40	30	19	18	0	3
9 5	Painful amputation stump	40	21	13	27	0	0
8 8	Tuberculosis	37	37	9	19	3	6
8 5	Diabetes (gangrene)	36	28	21	15	0	0
8 5	Arteriosclerosis (gangrene)	36	35	29	7	0	0
7 1	Sarcoma	30	28	21	3	6	0
2.6	Carcinoma	11	11	3	4	1	3
2 3	Thrombosis and embolism	10	9	7	2	1	0
1.9	Gas bacillus infection	8	8	4	1	1	2
0 9	Ununited fracture	4	4	3	1	0	0
0 7	Ruptured brachial plexus	3	3	0	0	3	0
0 7	Spina bifida	3	1	0	3	0	0
0.4	Charcot joint	2	1	1	1	0	0
0 2	Foot deformity (contracture)	1	1	0	1	0	0
0 2	Trophic ulcer	1	1	0	1	0	0
0 2	Tetanus	1	1	1	0	0	0
0 2	Pressure of pelvic tumor	1	1	1	0	0	0
0 2	Gangrene after ligation for popliteal aneurysm	1	1	0	1	0	0
		420	360	179	160	38	43

Types of Amputation (420 Cases)

	Number	Per cent
Amputation thigh	155	37 0
Amputation lower leg	152	36 0
Amputation forearm	13	12 0
Amputation upper arm	30	7 0
Gritti-Stokes amputation	13	3 0
Disarticulation hip	9	2 0
Disarticulation shoulder	8	2 0
Syme amputation	6	1.4
Amputation through tarsus	3	0.7
Disarticulation knee	1	0 2
	420	

The reader is referred to an article by Kuhns and Wilson in the *Archives of Surgery*, April, 1928

If bleeding is carefully arrested, there is no reason for the use of drains. When infection is feared, it is better to leave the stump open

than to close it with drainage They advise either tight closure or complete exposure

Of the patients with amputations of the lower leg, 85 per cent used appliances Although the functional results of such amputations were usually better than those of amputations of the thigh, a larger propor-

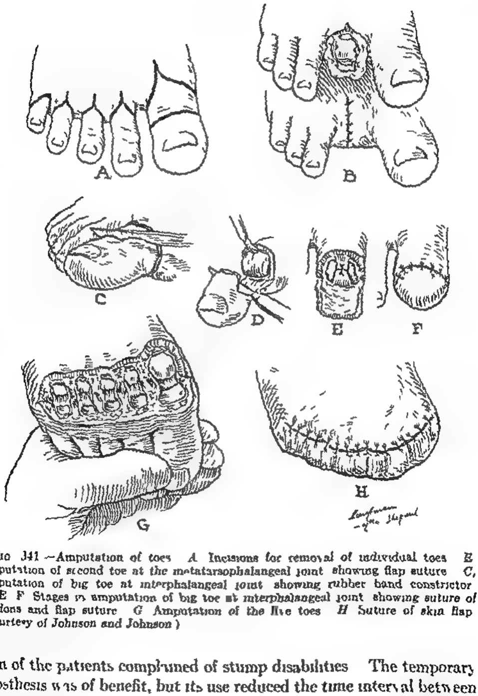


FIG 341 —Amputation of toes *A* Incisions for removal of individual toes *B* Amputation of second toe at the metatarsophalangeal joint showing flap suture *C*, Amputation of big toe at interphalangeal joint showing rubber band constrictor *D E F* Stages in amputation of big toe at interphalangeal joint showing suture of tendons and flap suture *G* Amputation of the five toes *H* Suture of skin flap (Courtesy of Johnson and Johnson)

tion of the patients complained of stump disabilities The temporary prosthesis was of benefit, but its use reduced the time interval between operation and delivery of the permanent limb less than in the case of amputations of the thigh

The results of the Syme amputation were satisfactory in 5 of 6

patients. All of the 5 patients had stumps capable of direct end-bearing, and the majority were doing heavy work.

The After-care of Amputations.—The postoperative care includes bandaging, protection, and splinting.

To lessen the amount of edema of a stump, elevation upon pillows is necessary immediately following the operation, but must not be continued where a flexion deformity will result.

Early active motion of the stump is essential to reëstablish the circulation and to prevent atrophy of muscles. After the wound is healed, massage is an additional aid in the reëstablishment of proper circulation. At the same time pressure exercises should be started. The preparation for prostheses includes massage, manipulation, "toughening" of the tissues, and contrast baths.

The mental attitude of the patient who has had an amputation must be considered in the after-treatment. He must be encouraged during the entire period of treatment and reassured that he can return to his former occupation or choose some form of new occupation which will keep him happy.

Physical Therapy in the Treatment of Amputation Stumps.—Titus advises whirlpool baths for at least six weeks in daily treatments, if possible. This serves to toughen the skin. When the skin is normal in appearance and the tissues have contracted, contrast baths are of definite value.

Massage, when given to these patients, should not be limited to the distal end of the limb. The entire remaining leg, as well as the hip and lower back, should receive good massage. It is frequently necessary to massage the other leg, hip and both shoulders in patients unaccustomed to crutches.

When there is infection of a stump wound, which can possibly lead to an infection in the end of the bone, it is best to stimulate the terminal circulation as much as possible, but with minimal irritation. Open stumps can be treated in the whirlpool bath, using some bactericidal agent in the water.

Heat in the form of diathermy (deep) and infra-red (superficial) is of undeniable value. For stumps kept open by low-grade infections, the galvanic bath will often stimulate healing.

Complications.—The development of spurs is a manifestation of the proliferative reaction of bone or periosteum to infection or injury. It occurs frequently in infected stumps. The process is influenced by the extent of the injury to the periosteum and whether it has been stripped up extensively or not. The periosteal method of treating the bone is a safeguard against the development of small bone fragments. By this technic, a cuff of periosteum is removed from the distal end of the bone and the marrow is curetted for an equal distance to

remove the endosteum For an "above knee" limb, the amputation should be at least 4 inches above the condyles and, preferably, should preserve a stump measuring 10 or 12 inches from the great trochanter The ideal "below knee" stump includes 7 inches of tibia, but shorter stumps than this can be fitted

It is generally agreed that flaps should be no longer than the diameter of the limb and should contain no more muscle in their bases than is necessary to insure a sufficient blood supply Flaps must be so fashioned that a good plastic closure can be made without leaving redundant tissue which forms "dog ears"

Among the most frequent amputation problems are nerve disturbances The major nerves should be crushed and tied with minimal traction Some believe that alcohol injection produces a perineural fibrosis It is better to allow space between sutures for the exit of oozing blood than to introduce a drainage tube To afford rest and prevent flexion deformity, "below knee" stumps should be splinted and "above knee" stumps should be stabilized by a light sand bag placed above the stump

Pain in Amputated Stumps —Leclerc employed procain hydrochloride, simple nerve resection and lumbar sympathectomy in treating pain in amputated stumps Procain hydrochloride, though only rarely affording permanent relief, is regarded by the author as valuable in indicating further therapy For amputations of recent date and with localized pain, procain hydrochloride gives good temporary results In old and aggravated cases, in which the drug was unable to prevent recurrence of pain, satisfactory results were obtained by lumbar sympathectomy for the lower extremity In the mixed type of stump pains in which the remaining stump as well as the removed anatomical portion due to hyperesthesia was involved, favorable analgesic action of the drug indicated resection of the sympathetic chain and ganglion If this operation was ineffective, a simple nerve resection followed by prompt suture or grafting did the job Lumbar sympathectomy, in a limited number of cases, achieved remarkable results in relieving formication and vasomotor disorders Leclerc cited a remarkable case in which multiple operations had been performed for frozen feet since 1917 Seen in 1935, the patient was suffering agonizing pain The stump indicated vasomotor and trophic dysfunction and presented a neuroma at the site of the cicatrix Lumbar sympathectomy was done and all pain ceased on the evening of the same day, not to recur Seen in 1939, the patient was well and had qualified as a gamekeeper, though before that he had been unable to endure any artificial apparatus The author obtained better results by resection of the sympathetic chain and ganglions done either as the first operation or in order to correct unsatisfactory previous results,

than by all other therapeutic procedures, especially in the thoroughness with which the whole clinical picture was altered. This operation was the procedure of choice wherever procain hydrochloride was observed to alleviate pain. Simple nerve section for control of imaginary nostalgic pain in the severed limb, followed by prompt nerve reconstitution after using phenol at the central termination, was tried and abandoned as the method of choice. Periarterial sympathectomy, with the exception of 1 case, yielded only temporary relief.

Wirtschafter used ascorbic acid and histidine with remarkable effect in gangrenous limbs.

Disease Groups.—Traumatic amputations were twice as common as amputations based on any other cause. These were distributed fairly evenly between the two segments of the upper and lower limbs. Trauma accounted for 50 (61 per cent) of the 81 amputations of the upper extremity performed for all causes. Most of the amputations for sepsis were performed on the lower limb.

In cases of amputation for thrombo-angiitis obliterans and endarteritis, the results were unsatisfactory chiefly because of progression of the disease, involvement of the opposite limb, or the necessity for repeated amputation.

Of the patients subjected to amputation for tuberculosis, a large number died of tuberculous complications within two years after the operation.

Of those subjected to amputation for diabetic gangrene, only a few survived for more than a few years.

In both diabetic and arteriosclerotic gangrene, the best functional results were obtained with the Gritti-Stokes amputation.

Eight of 28 patients on whom amputation was performed for sarcoma have remained well for a number of years.

Persons with arteriosclerosis and diabetes constitute a group particularly susceptible to infections and gangrene of the lower extremities. The mortality from amputations in this group is still high, in spite of its reduction since the introduction of insulin in 1921.

Surgery on diabetics has been advanced by the surgical work of Jones and McKittrick and the medical work of Joslin. These investigators have emphasized, to the great benefit of septic patients with diabetes and gangrene, the efficacy of a guillotine amputation through the lower third of the leg. Artificial limb-makers should be credited for their coöperation in standardizing amputations. Much valuable information regarding artificial limbs and amputations was contributed also by the surgical experiences during World War II.

Reamputations.—Of the 360 cases of primary amputation, reamputation was required in 53 (14.7 per cent). First-intention healing was obtained in only 12 per cent. An important cause of reamputation

was painful nerve bulbs This result is probably to be attributed to employment of the alcohol injection technic The most common cause of reamputation was ulcer of the stump Amputations of the lower leg had been performed on 17 of 21 patients with ulcerated stumps and amputations of the thigh on 4 In the cases of 11 patients it was necessary to reamputate above the knee because of extending gangrene following a primary amputation of the lower leg

Amputation is
1 Irreversible, 2 Final, but it is 3 Substitutional The slogan oftentimes is **Your Life or Your Limb**

The first indication is to conserve the safety of the patient, the second, to secure a stump which will meet the demands to be made upon it by the artificial limb

Regardless of the method of amputation, the following rules should be observed *(1) The periosteum should be cut cleanly with a knife at* or slightly above the level at which the bone is to be divided, in order to prevent shredding of the periosteum and thereby diminish the chance of spur formation (2) The nerves should be drawn down strongly out of their sheaths and an inch or more should be removed in order to diminish the danger of their being caught in the scar and of overgrowth of the nerve ends (3) A sufficient amount of soft tissue should be secured over the end of the bone

In order to promote the highest standards of amputation surgery in the Army, five General Hospitals were designated as Amputation Centers in March, 1943 The Surgeon General has published information and directives relative to surgical principles, and has adopted a uniform system of prosthesis-fitting The program is sufficiently flexible to permit local variations and the trial of new appliances, so that progressive improvement may result Peterson outlined the policies of the program and presented a brief statistical summary

The open circular method of amputation was practised in World War I, and has been advocated since that time by military surgeons, as the procedure of choice in emergency amputations for trauma and infection The principles may be summarized as consisting of amputation "at the lowest possible level which permits removal of all devitalized and contaminated tissue, " and the immediate application of skin traction, which is to be continued until the stump heals It was contemplated that secondary revision of the stump would be done later at one of the Amputation Centers, where the amputee would subsequently be

fitted, and where he would be taught how to use the prothesis, before he was discharged. In this study, 78.4 per cent of the patients admitted to the Amputation Centers required secondary revision of the stump, which indicates the wide-spread use of the open type of amputation.

All major amputation cases were transferred to the appropriate centers as soon as the patient could be transported with safety.

While the surgical principles of the emergency open amputation have long been established, it would seem appropriate to invite attention to three difficulties encountered during the early period of World War II.

Poor stumps and outright failures result from faulty selection of cases, interference with the circulation of the flap from excessive dissection and undercutting faulty bone length and a loose wobbly pad of soft tissue and patella.

Tendinoplastic Method.—Excellent stumps many of which are quite capable of end bearing, are obtained by bone section in the lower third with the soft tissue incision at the patellar level. The circular incision is ideal. Short square flaps take care of the ears if annoying to the surgeon but tend to lead to unnecessary dissection.

Poor stumps often result from surgical errors:

1. Wrong choice of level and type of procedure.
2. Excessive soft tissue dissection, periosteal stripping, trauma, strangulation, ligatures and sutures.
3. Soft tissue closure under tension.
4. Redundant soft tissue.
5. Failure to use the open method when in doubt as to circulatory status and infection.
6. Neglect of postoperative conditioning of stump, joints, muscles and skin.

GOOD STUMPS ARE MADE BY GOOD SURGERY

1. Amputate through viable tissue, neither losing probably useful length nor risking the patient's life in attempting an elective closed amputation when a simple circular open amputation will conserve both.

2. Incise directly through each layer of tissue, the skin, fat and muscular fascia, the muscle, periosteum and the bone at successive levels, not slicing or undercutting or making extensive flaps. Freeing of connecting tissues of the several layers as at intermuscular septums is desirable. Cut the periosteum cleanly, leaving no shreds or flaps behind, and no spurs will form. Leave the bone end with a blood supply and avoid a ring sequestrum. Gentle retraction diminishes post-operative swelling. Careful hemostasis and minimal tissue within the

and sutures, shortens postoperative healing and reduces circulatory disturbances The stump will shrink less and hold up better

3 Avoid tension, it prevents free circulation This is a basic surgical principle Long flaps are not necessary Plan to have the correct ratio between soft tissue and bone length, don't leave it up to traction, handy stump saver that it is

4 Trim excessive soft tissue off now, it will save doing it later

5 Use the open method in cases of infection or potential infection Healing is often rapid Many stumps will be good without further surgery If not, secondary closure, plastic operation or reamputation will make them so

6 Use traction to maintain soft tissue length beyond the bone Contracting granulation tissue will do the rest When traction is unnecessary, a light plaster bandage rests the part—it heals better

7 Use active motion as healing permits, it improves circulation, frees joint motion, builds muscle Use an elastic bandage on congested stumps *Graduated friction and pressure accustom the stump to its* next job—a prosthesis for weight-bearing as soon as possible The skin must be kept clean, soap, water, air, and sun minimize minor cutaneous infections Early graduated weight-bearing on a well fitted prosthesis builds a healthy tough dermis Don't abuse it

The Amputation Stump From the Prosthetic Point of View* —An amputation may be urgently necessary or elective Once life has been saved, the usefulness of the stump becomes of paramount importance These two functions of amputation are often quite inseparable, the surgeon adapting the underlying principles according to the exigencies of the occasion

The loss of the toes causes little or no disability save for slight nondisabling loss of push off in vigorous walkers when the great toe is gone A filler pad in the shoe adds to the patient's comfort Place the scar dorsally and avoid disabling pain Amputation through the base of the proximal phalanx is slightly easier and less traumatizing than disarticulation

Metatarsals —Preserve length only if the plantar flap will cover the bone ends and leave a dorsal scar Carefully smooth the bone ends

Metatarsal-Tarsal (Lisfranc) Amputation —This fully end weight-bearing elective site is very good when sufficient normal plantar flap is available to cover the end and give a dorsal scar Preservation of the bases of the first and fifth metatarsals preserves better balance A carefully fitted arch support and toe pad in the shoe will improve function though the patient can walk without prosthesis or only a simple toe filler pad

* Vernon P Thompson

The Tarsal (Chopart) Amputation.—Amputation through the tarsus is not advised, since the muscle balance present in the Lisfranc is lacking. The next higher level is advised.

The Symes Amputation.—This amputation places the fully weight-bearing pad of the heel over the distal ends of the tibia and fibula just above the level of the ankle joint. Since this stump is useless unless fully end bearing, the tissue of the heel pad must be normal before operation, be accurately placed on the lower leg at the operation, which must not impair the vitality of the flap, and be maintained in good position until firmly united. Reamputation at a higher level months or years later may usually be avoided by proper selection of cases, careful technic, reasonable use of the stump by the patient and fortunate absence of progressive vascular disease. The prosthesis is too clumsy to be satisfactory for most women but gives excellent weight-bearing and a good push off on the ball of the artificial foot. The anterior scar should come just above the slight flare of the bones so as not to become irritated.

The incision consists of a transverse anterior portion and a vertical U passing under and in front of the heel from their common starting point at the malleolar level in the mid-axial line of the leg as seen laterally. An anterior oval incision is somewhat simpler and easier to close. It is carried deeply through skin to ankle joint capsule, lateral ligaments, periosteum and plantar fascia. The ankle joint capsule is incised transversely, the astragalus freed from the mortice ligaments and displaced anteriorly, so as to permit dissection of the os calcis out of the posterior heel flap. This is carried out just extraperiosteally, great pains being taken not to traumatize the exposed soft tissue of the flap. Everywhere the deepest layer of the superficial fascia is left intact, in many areas the deep fascia as well and, of course, the Achilles tendon. The muscles taking origin on the os calcis are left attached, though they may be dissected off the flap if originally included in it. The mortice is exposed by sharp extraperiosteal dissection and the malleoli sawed off one-fourth to one-half inch proximal to the tibial articular surface, the aperiosteal technic previously described being used.

After suitable ligation of the larger vessels the tourniquet is removed and as nearly perfect hemostasis as possible is obtained.

By this time the flap will have shrunk some, but the fitting of the long posterior flap to the anterior one takes judgment and patience. The bony stump must fit snugly in the center of the heel pad, which must not be permitted to slide sideways or forward. Ears may be judiciously trimmed but are usually better left alone. Small rubber drains in the corners and a snug pressure dressing maintaining the pad in place, complete the operation.

At the first dressing, when the drains are removed, the position of the heel pad should be carefully checked

The Lower Leg —Tibial stump length of 6½ to 7 inches is ideal, even 4½ inches of bone length will give good function But stumps with less than 2 inches length below the medial hamstrings are seldom effective Near or at the hamstring level, full end bearing may be obtained by fitting with the knee flexed 90 degrees, using a laced socket

The flaps should be broad, not pointed, the posterior one short, the anterior of medium length The fibula is exposed by a posterolateral extension of the flap incision Include the deepest layer of the superficial (fatty) layer in the incision The treatment of the muscle, periosteum and so on has been previously described The months so commonly necessary before fitting the prosthesis to lower leg stumps often have their basis in the trauma to the soft parts at operation Expose the fibula in the muscle plane, sharply cutting the muscular and septal attachments, remove the periosteum from above the level of osteotomy A Gigli saw obviates much retraction Cut the fibula off 1 to 2 inches above the tibial site Smooth the corners well In short lower leg stumps it is often advisable to remove the entire fibula When there is question as to the infectious status of the tissues do not do so, since the knee joint may be infected by continuity

There have been many unsatisfactory lower leg stumps Some experienced surgeons believe an end weight-bearing lower thigh stump, particularly the Gritti-Stokes, is preferable in the long run to even a good lower leg stump Generally the performance over many years of a good lower leg stump with a well serviced prosthesis will permit no needless sacrifice of the knee joint

Amputations at the Knee and Distal Thigh —Good condylar, Gritti-Stokes, capsuloplastic (Callander) and tendinoplastic (lower third) stumps permit considerable to complete end weight-bearing

All end bearing stumps at the knee and lower third must have a posterior scar Owing to the retraction of the hamstrings and the nonretraction of the relatively fixed quadriceps muscle, even the circular open method will result in a posterior scar if sufficient soft tissue is present

Even the time honored long anterior flap of the Gritti-Stokes amputation appears unnecessary after using a circular or oval incision with less dissection and vascular disturbance

The method of condylar amputation as shown by Perry Rogers has given excellent end bearing stumps In suitable cases it appears that the previously somewhat discredited condylar amputation at the knee merits serious consideration The outside knee joint of the prosthesis presents an esthetic objection as with other excessively long thigh stumps

Gritti-Stokes Method.—The essential feature of a good stump by this method is covering the bone end with an intact anterior flap of weight-bearing skin, subcutaneous tissue, prepatellar fascia and the anterior portion of the patella, which should unite to the end of the femur. Usually a long anterior and a short posterior flap are formed. It is not necessary or desirable to dissect the skin and subcutaneous flap from the underlying patellotendinous flap. Saw off the posterior articular half of the patella before sectioning the femur. Section the femur at (not above) the level of the upper pole of the patella as noted with the anterior flap lying in its natural position. This is at the upper part of the flare of the femoral condyles. The patella will then naturally lie over the end of the femur. It should not drop posteriorly as when the femur is cut too short.

Harris considers the Symes to be the most useful of all amputations of the lower extremity, because of the perfection of its weight-bearing qualities. The tibia and fibula are transected just above the level of the ankle joint. The lower fragments of these bones and the whole of the tarsus and metatarsus are removed, the heel flap being left to cover the ends of the tibia and fibula. It is the ideal operation, when amputation must be considered for destructive trauma of the fore-part of the foot. It is so much superior to amputation through the calf that it should be performed wherever possible. To this end, amputation in the field should save the heel, whenever possible, in order that Syme's amputation may be performed at a later date.

The Guillotine Amputation.—The guillotine or open amputation is based on the sound surgical principle of drainage for infection. The efficacy of the guillotine amputation as a life saving measure and a "length preserving" operation was definitely established in World War I. So lethal were the consequences of primary closure of battle wounds that it was necessary for the Surgeon General of the American Expeditionary Forces to issue an order prohibiting the closure by primary suture of any battle wound.

Colonel MacFarlane the consulting surgeon to the Canadian Ov seas Force, in commenting on the results of chemotherapy in African campaign of 1941 emphasized the necessity for drain traumatic wounds. He stated that despite the liberal use of fonamides the battle casualties from this campaign invarial severely infected when closure of wounds was carried out. stated that patients whose wounds were left open and permi drain and heal by granulation recovered more quickly and with fatalities.

The same statement is made by Kirk and McKeever of our casualties returned to this country. In one group of 150 am which included patients from all theaters of operation

zone of the interior, the following facts were evident (1) The systemic status of the patients whose amputated extremities had been left open was universally excellent (2) The only patients showing the exhaustion of prolonged infection were those in whom the development of infection made imperative the opening of a previously sutured stump (3) The guillotined extremities all presented a good granulating surface, which was easily and in a short time prepared for closure (4) The only severely infected stumps were those in which closure was attempted and failed Their preparation for ultimate closure took longer than the preparation of those extremities which had been left open to granulate (5) In no instance was the closure of a properly managed guillotine stump complicated by severe infection, nor did it require lavish sacrifice of length

Kirk and McKeever believe the guillotine amputation is definitely indicated for any extremity which requires removal when infection is already established or in which the probabilities of contamination make the chances for primary healing questionable Thus it is the operation of election for an extremity which must be removed because of a severe joint infection or an infected compound fracture or for a severely traumatized extremity in which amputation becomes necessary because of injury to the circulation of soft tissues The operation is also to be chosen when operating conditions are not adequate The patient recovering from severe shock will tolerate a guillotine amputation, as it can be performed much more rapidly than a closed amputation and with less additional shock

The guillotine amputation is a two stage procedure The first stage is the removal of the damaged portion of the extremity After the open cross section resulting from this stage has healed by granulation and scar contracture, the second stage consists in the operative procedure to produce the final stump for a prosthesis This may be a simple plastic closure or it may be a reamputation at the site of election

Routine for Proper Stump Treatment —At each dressing while the incision is healing the stump should be moved to the full limit in the opposite direction to that in which a contracture is likely to develop In cases of stumps of the lower leg, the movement should be carried out in extension, and in those of the thigh in hyperextension and adduction While it is usually advisable to keep all stumps elevated while the patient is recumbent, in the case of thigh stumps, this position favors a flexion contracture To counteract this tendency in cases of amputation of the thigh, it is recommended that once or twice each day the pillow be removed from under the stump and placed under the buttock to allow the stump to drop into hyperextension In addition, advantage should be taken of the position in which the stump is dressed in order to guard against the tendency toward contracture

Gritti-Stokes Method.—The essential feature of a good stump by this method is covering the bone end with an intact anterior flap of weight-bearing skin, subcutaneous tissue, prepatellar fascia and the anterior portion of the patella, which should unite to the end of the femur. Usually a long anterior and a short posterior flap are formed. It is not necessary or desirable to dissect the skin and subcutaneous flap from the underlying patellotendinous flap. Saw off the posterior articular half of the patella before sectioning the femur. Section the femur at (not above) the level of the upper pole of the patella as noted with the anterior flap lying in its natural position. This is at the upper part of the flare of the femoral condyles. The patella will then naturally lie over the end of the femur. It should not drop posteriorly as when the femur is cut too short.

Harris considers the Symes to be the most useful of all amputations of the lower extremity, because of the perfection of its weight-bearing qualities. The tibia and fibula are transected just above the level of the ankle joint. The lower fragments of these bones and the whole of the tarsus and metatarsus are removed, the heel flap being left to cover the ends of the tibia and fibula. It is the ideal operation, when amputation must be considered for destructive trauma of the fore-part of the foot. It is so much superior to amputation through the calf that it should be performed wherever possible. To this end, amputation in the field should save the heel, whenever possible, in order that Syme's amputation may be performed at a later date.

The Guillotine Amputation.—The guillotine or open amputation is based on the sound surgical principle of drainage for infection. The efficacy of the guillotine amputation as a life saving measure and a "length preserving" operation was definitely established in World War I. So lethal were the consequences of primary closure of battle wounds that it was necessary for the Surgeon General of the American Expeditionary Forces to issue an order prohibiting the closure by primary suture of any battle wound.

Colonel MacFarlane the consulting surgeon to the Canadian Overseas Force, in commenting on the results of chemotherapy in the African campaign of 1941 emphasized the necessity for drainage in traumatic wounds. He stated that despite the liberal use of the sulfonamides the battle casualties from this campaign invariably were severely infected when closure of wounds was carried out. He also stated that patients whose wounds were left open and permitted to drain and heal by granulation recovered more quickly and with fewer fatalities.

The same statement is made by Kirk and McKeever of our own casualties returned to this country. In one group of 150 amputees, which included patients from all theaters of operation as well as the

zone of the interior, the following facts were evident (1) The systemic status of the patients whose amputated extremities had been left open was universally excellent (2) The only patients showing the exhaustion of prolonged infection were those in whom the development of infection made imperative the opening of a previously sutured stump (3) The guillotined extremities all presented a good granulating surface, which was easily and in a short time prepared for closure (4) The only severely infected stumps were those in which closure was attempted and failed Their preparation for ultimate closure took longer than the preparation of those extremities which had been left open to granulate (5) In no instance was the closure of a properly managed guillotine stump complicated by severe infection, nor did it require lavish sacrifice of length

Kirk and McKeever believe the guillotine amputation is definitely indicated for any extremity which requires removal when infection is already established or in which the probabilities of contamination make the chances for primary healing questionable Thus it is the operation of election for an extremity which must be removed because of a severe joint infection or an infected compound fracture or for a severely traumatized extremity in which amputation becomes necessary because of injury to the circulation of soft tissues The operation is also to be chosen when operating conditions are not adequate The patient recovering from severe shock will tolerate a guillotine amputation, as it can be performed much more rapidly than a closed amputation and with less additional shock

The guillotine amputation is a two stage procedure The first stage is the removal of the damaged portion of the extremity After the open cross section resulting from this stage has healed by granulation and scar contracture, the second stage consists in the operative procedure to produce the final stump for a prosthesis This may be a simple plastic closure or it may be a reamputation at the site of election

Routine for Proper Stump Treatment —At each dressing while the incision is healing the stump should be moved to the full limit in the opposite direction to that in which a contracture is likely to develop In cases of stumps of the lower leg, the movement should be carried out in extension, and in those of the thigh in hyperextension and adduction While it is usually advisable to keep all stumps elevated while the patient is recumbent, in the case of thigh stumps, this position favors a flexion contracture To counteract this tendency in cases of amputation of the thigh, it is recommended that once or twice each day the pillow be removed from under the stump and placed under the buttock to allow the stump to drop into hyperextension In addition, advantage should be taken of the position in which the stump is dressed in order to guard against the tendency toward contracture

CHAPTER XXX

TUMORS OF THE FOOT AND ANKLE

TUMORS of the foot involve the bones or the soft tissues. They may be benign or malignant. I am partial to Campbell's classification of bone tumors.

BONE TUMORS

1. *Primary*
2. *Metastatic*

Primary

1. Osteogenic
2. Non-osteogenic

Osteogenic

1. Benign
2. Malignant—sarcoma

Non-osteogenic

1. Benign
2. Malignant

Primary
- *Osteogenic*
  - *Benign*
    - Osteoma—Exostosis
    - Osteochondroma
    - Chondroma
    - Giant Cell (Osteoclastoma)
    - Xanthoma
  - *Malignant*
    - Sarcoma
      - Chondromyxosarcoma—primary—secondary
      - Osteoblastic
      - Chondroblastic
      - Chondrosarcoma
      - Osteolytic
- *Non-osteogenic*
  - *Benign*—Angioma
  - Malignant
    - Endothelial—Ewing—Myeloma
    - Myeloma
    - Periosteal Fibro-sarcoma

Metastatic
- Carcinoma
- Lymphadenoma
- Hypernephroma

TUMORS OF JOINT

1. *Benign*
2. *Malignant*

Benign

- Synovioma
- Lipoma
- Hemangioma
- Fibroma
- Xanthoma
- Endothelioma
- Osteochondromatosis

TUMORS OF SOFT TISSUES

Fibroma	Xanthoma
Neurofibroma	Hemangioma
Lipoma	Lymphangioma
Osteochondroma	Fibrosarcoma
Giant cell	Epithelioma

TUMORS OF TENDON SHEATHS

Benign	Malignant
Ganglion	Synovioma
Xanthomatous—Giant Cell Tumor	Spindle Cell Sarcoma
Lipoma	Chondrosarcoma
Hemangioma	
Lymphangioma	
Fibroma	
Osteochondroma	

PRIMARY TUMORS OF THE FOOT AND ANKLE

Originating Tissue

Synovial	Capsular
Bursal	Paracapsular

Benign

Chondroma	Xanthoma
Osteoma	Lipoma
Ganglioma	Myxoma
Neuroganglioma	Hemangioma
Fibroma	Lymphangioma
Cysts	

Malignant

1 Synovial Epithelioma
2 Sarcoma Fibrosarcoma
   Spindle Cell
   Round cell
   Giant Cell
3 Myxochondrosarcoma

TUMORS OF BONE

Tumors arising in the bones of the foot and ankle are rare, those involving the lower ends of the tibia or fibula occur more frequently than those originating in the foot The most frequently involved bone of the foot is the calcaneus, next the phalanges, much rarer are tumors arising in the metatarsals The astragalus and the other tarsal bones are only rarely involved

The most common osseous tumor involving the foot is the osteochondroma (exostosis) These tumors form bony skeletal outgrowths containing a small amount of cartilage, usually present at the most distal portion, and only occasionally constitute the larger portion of the tumor Histologically they consist of cancellous bone, and of cartilage which is of the adult type and undergoes calcification in its deeper layers These tumors are benign and are often regarded as exaggerations of normal bone Occasionally exostoses may be multiple and it is likely that this multiplicity represents a congenital dis-

turbance in the perichondrium. Rarely a malignant tumor (chondromyxosarcoma) may arise in an osteochondroma.

Some exostoses contain only cartilaginous elements, and are therefore called chondromas. If only the osseous elements are present, they are called osteomas.

Bone Cysts.—There are two types of cysts, one the result of a cystic osteitis fibrosa (von Recklinghausen's disease) and the other the result of giant cell tumors. As far as the former is concerned, more often

Fig. 312.—Cartilaginous osteochondroma of the tibia just above the ankle joint.

multiple cysts are found throughout the skeletal system and occasionally involve the lower end of the tibia and the os calcis. The bone overlying the cyst may be merely a shell. The cyst itself contains a clear yellow or whitish liquid, and may be traversed by bone lamellæ. The wall of the cyst may contain a small bony excrescence or may be smooth. Surrounding the cysts, newly formed blood-vessels and areas of hemorrhage may be found, sometimes extending into the cyst. The lining of the cyst is formed by connective tissue which may con-

tain giant cells A parathyroid tumor may be associated with this lesion Bone cysts may give rise to spontaneous (pathological) fracture

Giant Cell Tumors —Giant cell tumors may be either solid or cystic The tumor may be encapsulated by fibrous connective tissue, is often very soft, of cheesy consistency and of reddish-brown color There may be foci of calcification Microscopically the tumor consists of

Fig 343 —Cyst of os calcis in a patient who had in addition a giant cell tumor of the upper end of the tibia

many large multinucleated giant cells in addition to a large number of small, round cells, and somewhat oval or spindle-shaped cells The round cells have a relatively large nucleus, a small amount of cytoplasm and a clearly outlined nucleolus Mitotic figures may be present in these cells Areas of hemorrhage are common Occasionally small islets of bony structures are seen throughout the tumor, particularly at its periphery These giant cell tumors are benign, but

may recur. Occasionally malignant forms of giant cell tumors occur. It is difficult to decide whether or not these are true giant cell tumors or various forms of osteogenic sarcoma. There are instances, however, of otherwise typical giant cell tumors which histologically show an abundance of atypical mitotic figures and distinct variations in size, shape and staining quality of the round and spindle-shaped cells previously described.

Chondromyxomas are tumors composed principally of cartilage and on section may be of somewhat gelatinous appearance depending upon the amount of myxomatous tissue present. Occasionally these tumors may be very firm because of secondary calcification. They are of a grayish-yellow color but may contain darker areas, the result of hemorrhages. Histologically adult cartilage is present in addition to much of an eosinophilic stroma in which young cartilage cells may be seen as small islets. Within the stroma there are also present a number of spindle or stellate-shaped cells with cytoplasmic processes extending in three directions. Chondromyxomas occur relatively more frequently in the phalanges of the foot. Though these tumors are generally benign, they may recur, if not completely removed. It seems that the prognosis for these tumors depends upon the character of the myxomatous component.

Chondromyxosarcoma.—These tumors may arise from normal bones or occasionally from osteochondromas or chondromyxomas. They occur very rarely in the foot and ankle. Grossly they resemble chondromyxomas, but are usually softer in consistency, have cystic areas containing a gelatinous liquid and lead to destruction of bone. Histologically the tumors consist of very young connective tissue with stellate or spindle-shaped cells, some of which are surrounded by a light halo. They are often embedded in myxomatous tissue. Transition from fibrous tissue to cartilage and myxomatous changes are very significant. The chondromyxosarcoma is a frankly malignant tumor terminating fatally within a relatively short time.

Osteogenic Sarcoma.—Whereas the sclerosing form of osteogenic sarcoma occurs extremely rarely in the ankle and foot, the osteolytic form of osteogenic sarcoma though very rare, does occur in the ankle, arising either from the lower fibula or tibia, or the astragalus. This fast growing tumor leads to early bone destruction and is characterized histologically by the presence of large spindle-shaped cells and round osteoblasts with many atypical mitotic figures and a high degree of anaplasia. There is also present a poorly formed intercellular osteoid tissue. The tumors involve the periosteum early. These sarcomas are highly malignant and pulmonary metastases readily occur.

Ewing's Tumor.—Though Ewing's tumor usually involves the shafts of long bones, there are instances on record of involvement of the os

calcis The lower ends of the tibia or fibula also may be the sites of this tumor The tumor mass is usually found just beneath the periosteum with a new formation of subperiosteal and endosteal bone As a result of growth of the tumor and hemorrhage, a separation of the periosteum from the cortex occurs and parallel deposits of new bone appear This gives the characteristic onion-peel formation as seen in the roentgenogram Histologically the tumor is composed of small round or somewhat spindle-shaped cells with dense nuclei The round cells may simulate those seen in lymphosarcoma The tumor either may produce metastases in other bones or what is regarded as metastases may be evidence of a multicentric origin

Metastatic carcinoma to the bones of the foot is extremely rare and is said to occur only if other bones are involved Of 1,742 tumors reviewed at Johns Hopkins Hospital, Moore found that 33 involved the os calcis Exostoses were the most common Chondroma, chondrosarcoma and Ewing's tumor composed the remainder In *metastatic carcinoma, roentgen irradiation prolongs life* and relieves pain to a surprising degree

TUMORS OF SOFT TISSUE

Articular Lipomas of the Lower Extremities —Deeply situated lipomas cause pain and pressure on the neighboring structures, especially the nerves Driels observed a lipoma the size of an apple between the first and second metatarsal bones, which prevented the wearing of a shoe

Lipomas in the periosteum and in the muscles are often very large Lipomas in the tendon sheaths appear as expansive, widely ramified lesions called lipoma arborescens

Driels made an extensive study of symmetrical lipomas of the upper ankle joints in patients with flat-foot or incomplete flat-foot *A swelling of the soft parts is present below and in front of the external malleolus* Surgery is recommended

Paramalleolar Lipomas —Paramalleolar lipomas are masses of fat which occur in and around the ankle joint While some of them surround the joint like a collarette, the majority occur below the external malleoli (Fig 344) The causes are unknown, but chronic irritation and obesity are factors The chief complaint is based upon esthetic features Pain may be a prominent symptom due to nerve pressure or stretching In some cases bursitis and lipoma may be indistinguishable before surgery is performed The treatment is surgical under local anesthesia

In one patient I found, on the right side, the superficial branch of the peroneal nerve was buried in fat and was giving off twigs This accounted for the pain and tenderness

Angioma of the Foot.—Primary angioma of bone is clinically uncommon in any part of the skeleton, but especially so in the bones of the extremities. Clinical manifestations appear only if the tumor has destroyed enough of the bone to cause its collapse, or has expanded the bone so that there is pressure on the adjacent soft tissues, causing pain or some functional disturbance. Asymptomatic angiomata of bones, notably the vertebræ, are found frequently at autopsy. Töpfer found an incidence of 11.93 per cent in 2,154 spines.

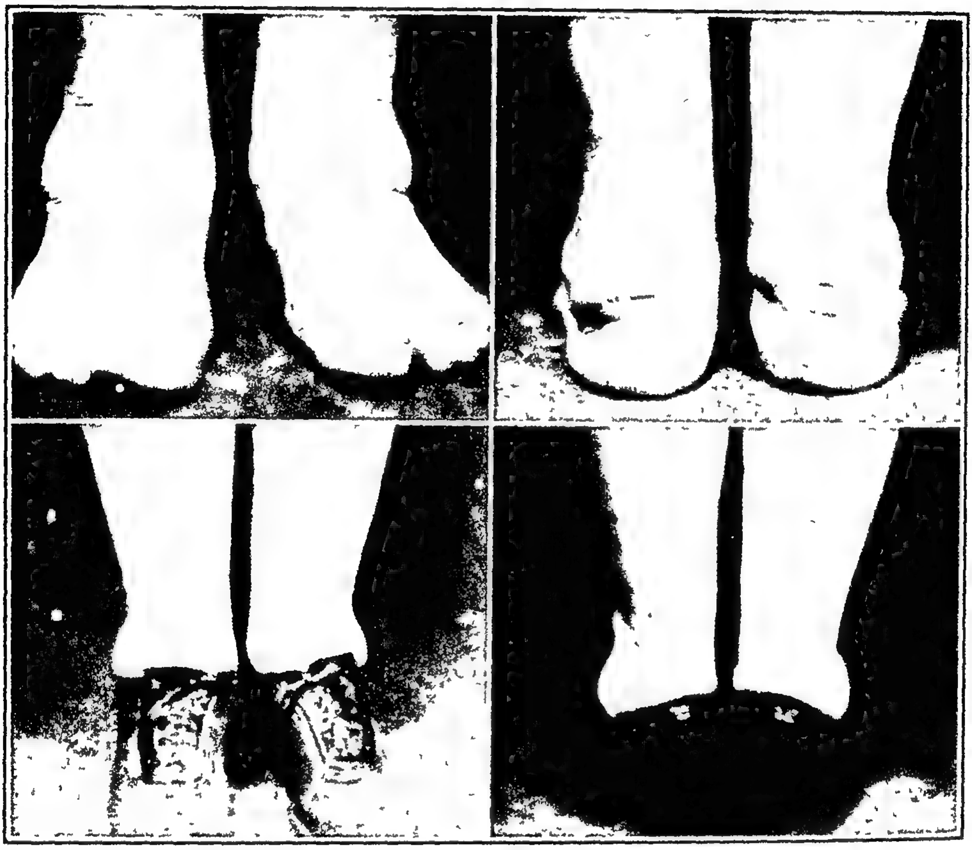


FIG. 314.—Fatty deposits encircling the ankles; these were removed by operation Comparable to "esil" bodies in the back; i. e., episacro iliac subfascial lipomas.

Kleinberg reported a case of a benign capillary hemangioma of a foot, involving the cuboid and the external cuneiform bones and the soft tissue in the sole of the foot. There was undoubted vascular communication between the lesion in the bones and that in the plantar area. It is not possible to state in which of these areas the angioma began. Perhaps, as in other cases with multiple lesions, the angioma appeared in the various areas simultaneously. The angiomatous growth evidently started many years previously, in childhood, and, while it had periodically caused some symptoms, these were not severe until shortly before the patient was seen by the author when, because of marked pain and disability, she was compelled to seek relief. The roentgenograms presented a characteristic multicystic appearance, yet

the diagnosis was not made until the time of operation, when the disappearance of the mass after a tourniquet was applied to the thigh suggested the probable pathology. Healing progressed very slowly and swelling of the foot persisted for a long time, but at the present time the patient has no symptoms and is apparently cured.

TUMORS OF THE TENDONS, JOINT CAPSULES AND SYNOVIA

A number of tumors are found in the foot and around the ankle which arise from *tendons, joint capsules* and the *synovia*. These tumors are often of a yellow color and because, on histological examination, they often are seen to contain giant cells, they are spoken of as xanthomatous giant cell tumors. They are mottled yellow or yellowish-brown, rather soft, round, and well circumscribed. To those which arise from the tendon sheaths and often in close relation to the joints or bones, the term "myelomas of tendon sheaths" is applied. Histologically these tumors consist of scattered round or oval cells, with a small amount of cytoplasm. Larger epithelial-like cells with slightly vesicular nuclei and a foamy cytoplasm which contains varying amounts of lipoids are also present. Multinucleated giant cells of the foreign body type are distributed irregularly throughout the tumor.

Synoviomas.—Synoviomas arise from the synovial membranes whose structures are reproduced by these tumors. They are rare and can be diagnosed only upon histological examination. They are said to be highly malignant. However, the degree of their malignancy can be determined only after a microscopic study.

Ganglion.—It is questionable whether ganglia should be classified among tumors, or whether they are the result of chronic irritation and trauma and should be regarded as products of irritation. They are firm, round nodes consisting of a dense fibrous capsule which encloses a clear viscid fluid. They are found more frequently on the dorsal aspect of the ankle or foot. They may also arise from tendon sheaths.

TUMORS OF NERVES

Neuromas.—Neuromas arise from the trunks or branches of nerves, or at the ends of severed nerves. They are often found in the stump of an amputated limb, and give rise to pain. Excision of the tumor relieves the pain.

Neurofibromas.—Neurofibromas may occur in connection with tendon sheaths or may be found in the subcutaneous tissue. They are hard, and may cause pain. In von Recklinghausen's disease, they are multiple and occur in any part of the body. However, they may occur singly. Microscopically, they are composed of fibrous elements, with a fine reticulum of neurogenic tissue and contain giant cells.

Neurofibrosarcoma.—Neurofibrosarcoma is the malignant form of neurofibroma. It is radioresistant, but if excised, rarely recurs.

TUMORS OF SUBCUTANEOUS TISSUES

The chief soft tissue tumors are lipomas, melanomas, keloids, fibromas, neuromas, neurofibromas, xanthomas, hemangiomas, lymphangiomas, myomas, dermoids, lymphoblastomas, carcinomas, melanosarcomas, and melanoblastomas. Myxomas, angiomas, and lipomas may be present at birth.

Often the connective tissue tumors appear as small, circumscribed nodules covered by skin. Occasionally they are pedunculated. Fibromas are grayish-white; lipomas, yellow; neurofibromas, more pinkish-gray; and angiomas, grayish-white (lymphangiomas) or red or bluish-red (hemangiomas). Angiomas often are not true tumors but rather vascular malformations and hence should be classified as hematomas. Angioblastomas (angio-endotheliomas) are more cellular tumors and on histological examination may appear malignant (angiosarcoma). They rarely produce metastases, though they readily recur. Neurofibromas are relatively common. These tumors, though histologically benign, are not well demarcated and may, therefore, recur after incomplete removal. Angiomyoneuromas (glomus tumors) are rare painful tumors which may occur in the toenail bed and resemble hemangiomas. They are benign.

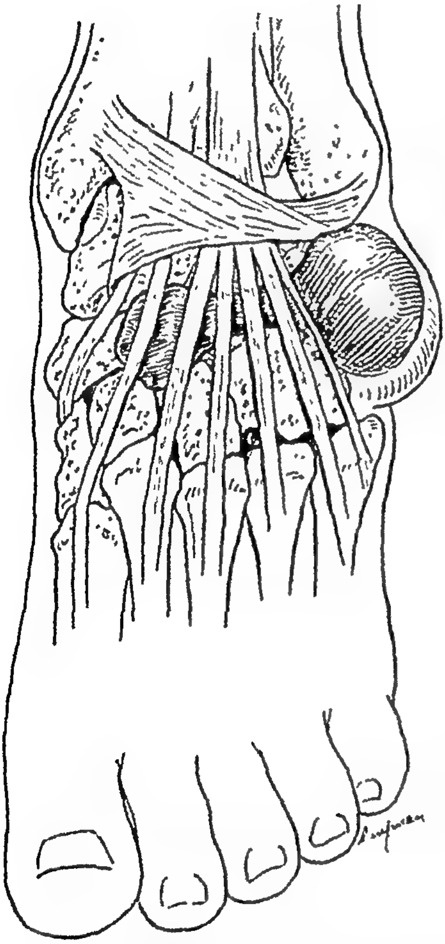


FIG. 315.—Cartilaginous tumor arising from the articular surface of the head of the astragalus, extending under flexor tendons in shape of a dumbbell and filling the sinus tarsi. Drawn at operation. (Courtesy of Dr. S. Sideman.)

Sebaceous cysts arise in the subcutaneous tissue and are covered by skin. They vary in size, are round, easily movable, of firm and fluctuant consistency. They contain an inspissated, whitish sebaceous material. Histologically, compressed sebaceous glands are often seen in their walls. Dermoid (epidermoid) cysts arise as a result of misplaced epidermoid structures. The walls of these cysts are firmer than those of the sebaceous cysts and are firmly attached to the underlying structures. Such cysts often contain hair.

Sarcomas arising from soft tissues, such as neurofibrosarcomas may arise in the subcutaneous tissue As long as the fibrocellular component predominates, these tumors may recur locally but do not produce metastases The recurrent tumors may be much more cellular than the initial tumor Many of the spindle-cell sarcomas are of neurogenic origin Other spindle-cell sarcomas appear to arise from tendon sheaths, or joint capsules Round-cell sarcomas are fast growing, cellular tumors with little or no stroma arising from the soft tissue of the foot The cellular types of sarcomas present soft, pink, irregularly outlined tumor masses which early produce metastases in the lung Hemangioma, lymphangioma and granuloma occur in the foot and calf

TUMORS OF SKIN

Though the various tumors of the skin of the foot and ankle may be morphologically identical with other tumors which arise throughout the body, they differ from these in the frequency or rarity of their occurrence Whereas carcinomas are frequent on the exposed portions of the epidermis, their incidence on the foot is low The bones of the foot are hardly ever the seat of metastatic carcinomas but giant cell tumors and osteochondromas are found not infrequently Thus, skin tumors such as the hard papilloma and carcinoma occur infrequently

Papillomas —Papillomas are benign tumors, usually of small size and are more commonly found on the sole of the foot arising at the site of a callus A papilloma may be due to infection I have had patients with papillomas who had been treated by roentgen-rays, radium, glacial acetic acid, bichloracetic acid, nitric acid, silver nitrate, trimming, by complete excision by surgery, electric cautery, and numerous other agents, but failed to be cured until their shoes were properly selected and modified without and within to remove the pressure from the involved areas

Hard papillomas must be differentiated from focal hyperkeratinization as seen in the common corn

Keloids —Keloids are the result of an excess amount of fibrous connective tissue forming in a scar Some individuals, especially negroes, are known as "keloid formers" In other cases, the excess of fibrous tissue may be due to constant irritation, as from a shoe Keloids may grow to huge proportions

Melanomas —Skin cancer may develop from *pigmented moles* There is always danger that a mole or nevus may become the point of origin of a highly malignant and widely spreading tumor known as "melanoma" Injury of a mole or its irritation by clothing or shoes favors the development of melanoma Excision is a proper procedure provided the excision is complete and includes a comparatively wide zone of healthy tissue around the mole Melanomas develop not infrequently after incomplete extirpation of moles The excision of a

mole may be followed by rapid and extensive metastasis. In cases of nevi, the great danger is the possibility of melanosarcoma or melanocarcinoma. All nevi should be excised widely and deeply.

Xanthomas.—Xanthomas may occur as one of two types. *Xanthoma diabeticorum* is manifested by millet seed to bean-sized, fawn to yellow colored lesions, occurring especially on the extensor surfaces of forearms, elbows, legs, and buttocks. Not rarely, they are seen on the dorsum of the feet. They may be discrete, or coalesce to form patches. There is always an associated glycosuria. *Xanthoma tuberosum multiplex* is manifested by yellowish to brownish opaque, well-defined, macules, nodules or tumors, occurring principally about the larger joints, although any part of the skin may be involved. There is usually an associated jaundice.

Keratosis.—A *senile keratosis* is potentially malignant. The majority of senile keratoses remain such, often over a period of many years, without giving rise to true malignancy. The incidence of carcinoma may be expressed by the fact that 5 to 10 per cent of cutaneous carcinomas occur on the hand and foot. Because such factors as chemical irritation, scars from burns and roentgen-ray lesions supposedly play a rôle in the development of carcinoma, it occurs much more frequently in the skin covering the hand. Carcinoma of the skin covering the foot is much more rarely encountered than carcinoma of the hand. Depending upon the age of the carcinoma, it may present itself in the form of a flat, firm nodule, as a cauliflower mass or as an ulcer with a firm, indurated margin.

Squamous Cell Carcinoma.—Squamous cell carcinoma of the extremities is more common in males than in females. Its incidence is higher than that of any other malignancy. Trauma is an important contributing factor. Metastasis is rare and occurs late.

The ulcerating type causes a great deal of destruction of the underlying tissues. The non-ulcerating type is more malignant.

The treatment in the majority of cases is surgical. Radiation therapy is indicated in the superficial ulcerating types which are not amenable to conservative surgery. Though histologically malignant, squamous cell carcinoma runs a relatively benign course.

Hemorrhagic Sarcoma.—This lesion may occur in the skin covering the foot and ankle. The skin of other parts of the body may also be simultaneously involved, since often multiple lesions are present. Localized edema, vascular *ectasiæ* and slight inflammation may be the initial lesions which gradually progress to tumor growth. The tumors

l bluish nodules of rubbery consistency, which
ıay coalesce. Occasionally they are cystic.
ion observed grossly. Histologi-
ature, associated with an
ıast cells. Later pro-

liferations of endothelial and of perivascularly arranged spindle-shaped and round cells are encountered, suggesting the presence of an angiosarcoma. It has been suggested that this lesion is an infectious granuloma.

Malignant Melanotic Tumors.—These have been described as melanomas, and melanosarcomas, but Hertzler and Gibson prefer to call them "melanoblastomas." They *originate from* the chromatophores, the stimulating factor usually being trauma. They are ulcerous or fungoid lesions which develop more frequently on the plantar than on the dorsal surface of the foot and tend to recur after excision. They metastasize by the lymphatic route.

Every suspicious neoplasm should be completely eradicated. Twenty years ago I removed a melanosarcoma from the skin of the dorsum of a man's foot just below the lower edge of the tibia. The operation was followed by radium therapy. To date, there has been no evidence of recurrence.

Melanotic Carcinoma (Melanosarcoma).—This occasionally occurs subungually or just between the toes. Because of pain in the former location, it is easily recognized but sometimes diagnosed late. In the latter location it may escape notice and may not be diagnosed until inguinal metastases present themselves. The outstanding feature of these tumors is their almost coal-black color.

Melanoblastoma of the Nail Bed (Melanotic Whitlow).—This is a malignant disease of the nail bed characterized by the formation of nodules of neoplastic tissue about the borders and beneath the nails. The growth is characterized by the formation of melanin and a tendency to spread by way of the lymphatics.

Malignant tumors of the nail bed are most frequent in the seventh and eighth decades of life. Melanoblastoma may start from a subungual pigmented mole. The cells lie beneath the epidermis, particularly along the blood-vessels.

Jaffé found the demonstration of pigmented areas to be of great importance in the differentiation of melanoblastoma from benign granuloma and *squamous* cell carcinoma. Carcinoma of the nail bed shows a dry and waxy surface. The appearance of a slowly developing granular area with a pigmented border is characteristic of melanoblastoma. Careful examination for this condition should be made in all cases of ulcerative lesions of the nail beds in elderly persons which do not show any tendency to heal. Apparently, all patients so afflicted sooner or later die from the disease except those treated by early amputation. The tendency is toward local recurrence spreading particularly to the neighboring lymph nodes or along the lymphatics.

The treatment is early radical operation. Most authors agree that roentgen-ray and radium are ineffective.

mole may be followed by rapid and extensive metastasis. In cases of nevi, the great danger is the possibility of melanosarcoma or melanocarcinoma. All nevi should be excised widely and deeply.

Xanthomas.—Xanthomas may occur as one of two types. *Xanthoma diabeticorum* is manifested by millet seed to bean-sized, fawn to yellow colored lesions, occurring especially on the extensor surfaces of forearms, elbows, legs, and buttocks. Not rarely, they are seen on the dorsum of the feet. They may be discrete, or coalesce to form patches. There is always an associated glycosuria. *Xanthoma tuberosum multiplex* is manifested by yellowish to brownish opaque, well-defined, macules, nodules or tumors, occurring principally about the larger joints, although any part of the skin may be involved. There is usually an associated jaundice.

Keratosis.—A *senile keratosis* is potentially malignant. The majority of senile keratoses remain such, often over a period of many years, without giving rise to true malignancy. The incidence of carcinoma may be expressed by the fact that 5 to 10 per cent of cutaneous carcinomas occur on the hand and foot. Because such factors as chemical irritation, scars from burns and roentgen-ray lesions supposedly play a rôle in the development of carcinoma, it occurs much more frequently in the skin covering the hand. Carcinoma of the skin covering the foot is much more rarely encountered than carcinoma of the hand. Depending upon the age of the carcinoma, it may present itself in the form of a flat, firm nodule, as a cauliflower mass or as an ulcer with a firm, indurated margin.

Squamous Cell Carcinoma.—Squamous cell carcinoma of the extremities is more common in males than in females. Its incidence is higher than that of any other malignancy. Trauma is an important contributing factor. Metastasis is rare and occurs late.

The ulcerating type causes a great deal of destruction of the underlying tissues. The non-ulcerating type is more malignant.

The treatment in the majority of cases is surgical. Radiation therapy is indicated in the superficial ulcerating types which are not amenable to conservative surgery. Though histologically malignant, squamous cell carcinoma runs a relatively benign course.

Hemorrhagic Sarcoma.—This lesion may occur in the skin covering the foot and ankle. The skin of other parts of the body may also be simultaneously involved, since often multiple lesions are present. Localized edema, vascular *ectasiæ* and slight inflammation may be the initial lesions which gradually progress to tumor growth. The tumors consist of multiple small bluish nodules of rubbery consistency, which are poorly defined and may coalesce. Occasionally they are cystic. Hemorrhage and pigmentation are often observed grossly. Histologically, dilated vessels are the prominent feature, associated with an infiltration of lymphocytes, plasma cells and mast cells. Later pro-

liferations of endothelial and of perivascularly arranged spindle-shaped and round cells are encountered, suggesting the presence of an angiosarcoma. It has been suggested that this lesion is an infectious granuloma.

Malignant Melanotic Tumors.—These have been described as melanomas, and melanosarcomas, but Hertzler and Gibson prefer to call them "melanoblastomas." They originate from the chromatophores, the stimulating factor usually being trauma. They are ulcerous or fungoid lesions which develop more frequently on the plantar than on the dorsal surface of the foot and tend to recur after excision. They metastasize by the lymphatic route.

Every suspicious neoplasm should be completely eradicated. Twenty years ago I removed a melanosarcoma from the skin of the dorsum of a man's foot just below the lower edge of the tibia. The operation was followed by radium therapy. To date, there has been no evidence of recurrence.

Melanotic Carcinoma (Melanosarcoma).—This occasionally occurs subungually or just between the toes. Because of pain in the former location, it is easily recognized but sometimes diagnosed late. In the latter location it may escape notice and may not be diagnosed until inguinal metastases present themselves. The outstanding feature of these tumors is their almost coal-black color.

Melanoblastoma of the Nail Bed (Melanotic Whitlow).—This is a malignant disease of the nail bed characterized by the formation of nodules of neoplastic tissue about the borders and beneath the nails. The growth is characterized by the formation of melanin and a tendency to spread by way of the lymphatics.

Malignant tumors of the nail bed are most frequent in the seventh and eighth decades of life. Melanoblastoma may start from a subungual pigmented mole. The cells lie beneath the epidermis, particularly along the blood-vessels.

Jaffé found the demonstration of pigmented areas to be of great importance in the differentiation of melanoblastoma from benign granuloma and squamous cell carcinoma. Carcinoma of the nail bed shows a dry and waxy surface. The appearance of a slowly developing granular area with a pigmented border is characteristic of melanoblastoma. Careful examination for this condition should be made in all cases of ulcerative lesions of the nail beds in elderly persons which do not show any tendency to heal. Apparently, all patients so afflicted sooner or later die from the disease except those treated by early amputation. The tendency is toward local recurrence spreading particularly to the neighboring lymph nodes or along the lymphatics.

The treatment is early radical operation. Most authors agree that roentgen-ray and radium are ineffective.

CHAPTER XXXI

DERMATOLOGICAL AFFECTIONS OF THE FOOT AND ANKLE

The most common dermatological disorders of the foot and ankle are: ringworm, eczema, psoriasis, scleroderma, corns, calluses, warts, fissures, abrasions, blisters, lesions of the toenails, melanoblastomas of the nail bed, hyperidrosis, diabetic gangrene, and ulcers. Ulcers may be due to arteriosclerosis, varicose veins, diabetes, neurological lesions or pressure. Trench foot is described in Chapter XXXII.

In some conditions the best therapeutic results are obtained by co-operation of the surgeon with the dermatologist. Such conditions are· burns, frostbite, infections, erysipelas, furuncles, carbuncles, paronychia, cellulitis, felons, lymphangitis, ganglions, papillomas, epitheliomas, sarcomas, melanomas, chronic ulcers of the leg, perforating ulcers, calluses, corns, warts, sebaceous cysts, glomus tumors, nevi, fibromas, onychomycosis, and granuloma pyogenicum.

Frostbite is of interest to the surgeon because it may necessitate amputation. Chilblains are of more interest to the dermatologist as they often respond to roentgen and local therapy.

In the prophylaxis and the treatment of plantar warts the most important factor is a proper shoe, especially one of good length. After the operative removal of such warts there may be a painful scar and recurrence may develop unless weight is removed from the involved area.

Many dermatoses which come primarily to the attention of the dermatologist may lead to complications requiring surgical intervention. Ulceration may result from the scratching of a streptococcic infection or the breaking down of an underlying varicose vein. Chronic streptococcic ulcer of the leg may respond to sulfanilamide or penicillin.

Blisters.—Blisters are produced by the separation of layers of skin and the accumulation of serum between the layers. They occur most commonly during athletics, especially games such as handball and tennis in which the players make quick stops and leaps. On ballet dancers' feet they are produced by the leaping and pounding. A common cause is a reduplication of a sock or the lining of a golf shoe. Irregularities in shoes are responsible for many blisters. The prophylaxis is indicated by the causes. The treatment is a small puncture with a sterile scalpel or scissors after the skin has been prepared with iodine and alcohol.

Fissures.—Fissures or cracks are due to dryness of the skin, hypothyroidism, or occupational factors. They are especially common between toes of feet which perspire excessively or which are not dried adequately after bathing. The application of a little compound tincture of benzoin by means of a cotton toothpick applicator, followed by strapping of the toes together to prevent recurrence of the cracking, is advised. Bismuth formic iodide and sulfo-merthiolate powders are helpful preventatives, but should not be used in the treatment of fissures, because of the danger of caking.

Abrasions.—Abrasions may lead to serious infection and should, therefore, be treated aseptically and antiseptically.

Calluses—Callosities.—A callus is an exaggerated hypertrophic accretion of the horny layers of the skin over circumscribed areas which have been subjected to pressure or irritation. Continuous pressure causes an ulcer, intermittent pressure, a callus. Calluses may be due to ill-fitting shoes or irregularities in the shoe such as may be produced by nails, and tacks. They vary in size and occur chiefly on the portions of the skin subjected to long-continued intermittent pressure from ill-fitting shoes especially on the heel, ball, or big toe. They are produced by such external causes as pressure, friction, chemical agents, and heat. Inflammation may occur in the subjacent tissues causing dermatitis, lymphangitis, and necrosis.

The treatment includes proper shoes with padding to prevent weight-bearing on the affected parts, removal of the growth by means of the knife, an electric needle, or fulguration, roentgen or radium therapy or cauterization with a chemical substance such as nitric or glacial acetic acid, silver nitrate, or bichloracetic acid. A cork insole with a hole cut over the callus, and bevelled edges, plus the local application of salicylic acid in collodion may be effective. The use of an emery board is of value when the corn is dry. Castor oil can be applied after using the emery board. This method is of especial value when diabetes is present and radical excision is injudicious.

Ochsner treats calluses with bichloracetic acid as follows: The lesion is first isolated by painting a thin film of vaseline around it. Two or three coats of bichloracetic acid are then applied by means of a glass rod at intervals of one or two minutes. After the area has been thoroughly soaked, the vaseline is removed completely with a cotton pledget, the area covered with a thin film of flexible collodion, and the patient instructed to return in from three to five days. On the patient's return, the hardened area is cut off with a sharp scalpel and the treatment is repeated. From two to four treatments are sufficient, providing the patient wears properly fitting shoes.

Common Hyperkeratotic Lesions of the Foot.—The high percentage of those who have been rejected or deferred because of foot defects

among civilians called to the armed services bears out the often quoted saying that no part of the body is more neglected in general medical practice than the feet. A recent article titled "Health of Selective Service Registrants" by Montgomery and Montgomery states that 30,000 of a total of 720,000 examined were unqualified for general military service because of foot defects. Of these, 21,000 were qualified for limited military service and 9,000 were disqualified for any military service.

The common hyperkeratotic lesions of the feet are: keratosis blennorrhagica, arsenical keratoses, congenital keratosis palmaris et plantaris and climacteric hyperkeratosis occur so rarely that they are of interest only to the dermatologist. The common lesions for which the physician in general practice can do much are callus, clavus and verruca.

Ordinary callus is a circumscribed or a diffuse hyperkeratotic or indurated area of the skin. The area may be covered with loosely adherent flaky corneous tissue masking the papillary lines. At times this horny mass may be ¼ inch thick and very firm. When this is shaved off, the papillary lines are clearly visible and are not interrupted or broken. There is no central core, and thus a callus is differentiated from a corn. A callus results almost invariably from unusual friction or pressure or both. On the foot it is due either to faulty footgear or some orthopedic condition, such as displacement of the head of one or more metatarsal bones. A callus may cause a burning sensation or definite pain.

Treatment.—Paring, shielding and wearing properly fitting shoes usually effect a cure. The callus is gradually thinned by shaving carefully with a sharp scalpel until the skin is of nearly normal thickness. Moleskin adhesive plaster is placed over the area. A thicker felt pad or a foam rubber one may be placed behind the callus to raise a depressed metatarsal head. Before shaving, applications of 40 per cent salicylic acid may be used to thin the callus.

Excision of a callus is not recommended, because a painful scar frequently results in its place. Roentgen therapy is usually unnecessary and is inadequate unless the pressure is permanently removed. It is to be condemned in cases in which the plantar fat pad has been thinned.

When pressure results in central vascularization of the callus, roentgen-rays are of value to relieve pain and desiccate the capillaries. The rays should be given to the central vascularized part only, in doses of 300 to 600 roentgens. The Montgomerys have found much damage from large doses of roentgen-rays or radium given to large areas. The formation of an ulcer is the most common harmful result of over-irradiation of a callus.

The coöperation of an orthopedist and a dermatologist is advisable.

A metatarsal crescent properly placed behind the metatarsal heads may give pronounced relief in the case of callus

Plantar Warts.—Plantar warts appear as hyperkeratotic areas on the sole of the foot, usually at the level of the heads of the metatarsals and contain a "core" or central structure. Any painful callus should be searched for the presence of a wart. Often such warts do not project above the surrounding skin on weight-bearing surfaces, but are flat and usually surrounded by callus formation. Small, reddish or brownish black dots may be seen through the callus or will become evident by moistening the callus or paring away the less translucent superficial layers. These dots represent the capillary loops of the wart.

The question of an infectious etiology is still unsettled. There is no doubt that faulty weight-bearing plays an important rôle.

Many forms of treatment have been offered, probably because some plantar warts disappear spontaneously and their cause is unknown. Occasionally a change in footgear or of hose, wearing cotton instead of wool or silk will hasten their departure. Massaging daily with castor oil may prove helpful. Relieving the weight-bearing over the area will not only diminish the pain, but will often result in a cure. This can be done by pads or by a metatarsal crescent on the sole.

Some good results have followed the employment of the whirlpool bath, causing the wart to extrude. After two or three such treatments they can often be removed with a pair of tweezers with no pain.

While there are scores of correctives, varying from the injection or application of caustics or acids to the application of radium or roentgen-ray, no single procedure will be effective in every instance. There will be failures no matter what regimen is utilized, and it is desirable to alternate the methods rather than use more of the same treatment.

When roentgen-ray is resorted to, it is rarely wise to repeat a large dose in the same area. Destruction of tissues may ensue with actual injury to circulation. There seems to be no risk, however, from a single sizable exposure, particularly if the spot is no larger than ½ inch in diameter. Fractional quantities, however, may be repeated without danger.

Electrodesiccation when properly carried out, gives excellent results. The absence of late after-effects and the certainty of complete eradication if done thoroughly under adequate local anesthesia compensate for the slight immediate discomfort. It is essential to desiccate thoroughly the soft, active base of the wart that lies deep beneath the callus.

Loop Treatment.—A preliminary report on a method of treatment for plantar warts by electrosurgical removal was published in 1942. It covered observations for only 21 patients. Since that time Karp has treated 100 additional patients with the same method, therefore, the

conclusion drawn in the preliminary report can be considered now as well established.

The high frequency cutting current is used as a means to destroy the plantar wart, and the source of the current should be a long wave diathermy machine capable of producing a cutting current of the necessary quality and quantity. Short wave diathermy machines are not generally satisfactory for the purpose.

In concluding this report, Karp states that out of the total of 127 patients (some with multiple lesions) treated by the loop method, only 7 have not responded favorably to the treatment. In this series of 127 patients many had received previous treatments, including roentgen irradiation, without benefit.

The percentage of cures in the 127 patients was 95.51 per cent. All warts were of the common plantar type. No mosaic plantar warts were treated.

Corns.—A corn is a localized overgrowth of skin with a central core. It is a circumscribed, cone-shaped hypertrophy of the horny layer of the epidermis, presenting inferiorly a prolongation which, when pressed from without inward upon the sensitive papillæ of the corium, excites pain. The hypertrophied epidermal and dermal layers become like dry scales or shells with a central hard core. This little concretion dips down and presses on the nerves beneath like a sharp pointed instrument. The cause of corns is continuous or intermittent pressure produced by improper shoes. Corns vary in size from that of a pea to that of a large chestnut, and commonly are described as "hard" or "soft." Hard corns are dense and rigid. They occur upon the parts of the foot on which the boot or shoe exercises its greatest pressure, such as the lateral side of the fifth toe and the dorsa of the three middle toes.

Corns are often weather-sensitive, being unusually painful just before, during, or immediately after the occurrence of storms. They should not be confounded with gouty or rheumatic deposits beneath the skin. Occasionally they become infected by pyogenic organisms, with resulting suppuration. Areas where a bone is displaced through subluxation, or deformed by lipping, or spurs, are usually the sites of corns.

The most common site for a hard corn is over the outer side of the small toe. A corn is sometimes found in a nail groove, on the tip of a small toe or on a pressure point on the sole of the foot. In the hard corn there is usually one core, but there may be several. Its shape depends on the contour of the bone beneath and may be round, crescentic or ridged.

An adventitious bursa may be found under the corn.

The soft corn is found most commonly in the interspace between the fourth and the fifth toes. It is usually in the most proximal portion

of the toe web or on the medial side of the little toe and appears macerated Frequently not until the macerated skin is pared away is the radix of the corn found It may be single but is usually double and is located over two opposing bony prominences Soft corns may be extremely painful The soft corn may be mistaken for the maceration one often sees in dermatophytosis

An ill fitting shoe may be a factor in producing a hard or soft corn by causing intermittent pressure over some bone or joint Palpation reveals a subjacent prominence An improper shoe may also upset the mechanics and muscle balance of the foot This may cause abnormal apposition of bony heads

Treatment —The prevention of corns depends primarily on a change to footgear of the proper size and shape Conservative therapy is preferred and consists mainly in paring and then protecting by shielding over bony prominences with felt, foam rubber or latex pads This palliative measure gives the patient temporary relief For permanent relief, Fripp and McConnell stress the restoration of proper muscle balance They advise proper exercises for the feet, faradic foot baths, adhesive strapping to prevent spreading of the metatarsal bones and properly fitted shoes

When treated by disuse of the feet or the application of a properly fitted covering, corns will often separate spontaneously They are frequently shed from the feet of paralyzed or bedridden persons They may be softened by prolonged maceration in water, or by oil, as in the treatment of callosities An effective corn paint suggested by C C Ross is made as follows

Glacial acetic acid	1 dram
Salicylic acid	50 gr
Cannabis indica	15 gr
Flexible collodion to make	1 oz

This paint can be applied twice daily to soften corns

Erasion, dissection, and excision may be advisable When use of the foot must be continued, the simplest and best treatment is as follows The part is macerated thoroughly for half an hour with water as hot as can be tolerated Then the projecting callus portion of the corn is removed by careful cutting or scraping until the surface is level with the plane of the adjacent skin, after which the part is dried, and the entire surface is covered completely with many narrow, short strips of rubber plaster Burgundy-pitch melted and painted over the part may be applied as a substitute for the plaster When the operation and dressing are complete the patient should be able to bear firm pressure over the corn and to walk with comfort In the course of a few days the plaster separates spontaneously The corn is then macerated at night with oil poultice and the dressing reapplied Persistence

in this course is followed by complete relief if the coverings of the feet are properly fitted. Carbon dioxide snow may be employed. Salicylic acid plasters are of service, and the pressure may be removed by applying a perforated felt covering or latex shield. Caustics such as glacial acetic and bichloracetic acid may be employed and are especially valuable for soft corns. Radiotherapy is useful in many instances.

Occasionally, radical excision of a hard corn and the adventitious bursa when present will effect a cure. The bony prominence underlying the corn may have to be removed. Operation for hammer toe, tenotomy or amputation of the fifth toe may be required.

Roentgen therapy helps in the relief of pain. It stops the active production of the horny mass making up the corn. Roentgen-rays are applied to the lesion with close lead shielding in doses of 800, 650 and 500 roentgens at ten day intervals. In the Montgomerys' experience, radiotherapy has never resulted in permanent benefit in the case of the common corn, hard or soft.

Local anesthetics injected in a fan-shaped area proximal to the corn, is effective. The corn may then be dissected out and a thin felt pad placed directly over the site. Injection alone relieves the pain and frequently effects a cure. Forty per cent salicylic acid plasters may be used with caution, but only on patients who are non-diabetic and who have normal vascular systems. If a hard corn is infected or shows a sinus, soothing wet dressings are indicated. A roentgenogram of the phalanx should be taken. The application of 95 per cent phenol or 50 per cent solution of silver nitrate to the sinus often aids in its closure. In the treatment of soft corns conservatism is advised. Surgery may be necessary.

In the treatment of corns, calluses, and warts, marginal felt pads are valuable because they protect the central portion from weight bearing. The application of adhesive pads softens the tissues so that they can be more easily separated from the normal tissues. Zinc oxide circular or oval adhesive pads with thick edges and thin central areas are often helpful. The continuous application of a 10 to 25 per cent salicylic plaster or mull or salicylated collodion paint is effective.

Salicylic acid has long been used to destroy warts. Nitric acid tends to produce keloidal scars. Radium will produce the same results as roentgen-rays in both callus and wart. The orthopædic surgeon and dermatologist should coöperate in the treatment. The most important factors in the prophylaxis and in the treatment of plantar warts are a proper shoe, especially one of good length, pads, heels, bars, and exercises. The warts may be operatively removed, but there is the possibility of a painful scar. After operations the sutures should be allowed to remain until healing is complete.

The "pneumatic" treatment of corns advocated by Unke is an

application of the principle of separation of tissues into layers This tears adhesions and small blood-vessels

The procedure does not remove the primary cause, i e, the bony knuckle However, it is probable that the patient by this time has purchased shoes large enough to accommodate the underlying situation

Regardless of whether it cures, it has evidence of merit Novocaine might be preferable Both are absorbed

Soft Corn —"Soft corn" is a painful condition, usually situated in the web between the fourth and fifth toes The keratinous layer of the skin of the web does not have a chance to undergo hypertrophic changes since it constantly becomes macerated and desquamated by the perspiration generated in the deep and poorly drained web between the fourth and fifth toes

Causative Factors
1 Approximation of tissues 2 Generation of heat that cannot radiate 3 Production of moisture that cannot evaporate 4 Irritation by rubbing of tissues over a prominence of bone (a miniature knuckle)

Soft corns are soft because they occur between the toes and are kept moist by perspiration Often intensely painful and, especially to diabetics and patients with vascular disease, dangerous sources of infection, soft corns can be most effectively treated by a simple surgical procedure

Causes

1 Approximation of skin
2 Heat that cannot radiate
3 Moisture that cannot evaporate

Spreading the toes apart corrects all three factors at once

It is a wise precaution not to bind two toes together before inserting some cotton or lamb's wool between them

There is danger of ringworm infestation superimposed upon infection

In most cases, with a change to more roomy footgear, further therapy comprises dissection of the radix of the corn with a special type of curved chisel, a "soft corn spoon," elevation of the head of the fourth metatarsal bone by a foam rubber shield and local application of 50 per cent silver nitrate solution to the pared corn Separation of the involved toes gives relief This is done by inserting a small piece of felt wedge shaped as a duck's bill, a piece of foam rubber or lamb's wool

There may be two complications in the case of soft corn, either of them serious in the presence of diabetes or of disease of the peripheral

in this course is followed by complete relief if the coverings of the feet are properly fitted. Carbon dioxide snow may be employed. Salicylic acid plasters are of service, and the pressure may be removed by applying a perforated felt covering or latex shield. Caustics such as glacial acetic and bichloracetic acid may be employed and are especially valuable for soft corns. Radiotherapy is useful in many instances.

Occasionally, radical excision of a hard corn and the adventitious bursa when present will effect a cure. The bony prominence underlying the corn may have to be removed. Operation for hammer toe, tenotomy or amputation of the fifth toe may be required.

Roentgen therapy helps in the relief of pain. It stops the active production of the horny mass making up the corn. Roentgen-rays are applied to the lesion with close lead shielding in doses of 800, 650 and 500 roentgens at ten day intervals. In the Montgomerys' experience, radiotherapy has never resulted in permanent benefit in the case of the common corn, hard or soft.

Local anesthetics injected in a fan-shaped area proximal to the corn, is effective. The corn may then be dissected out and a thin felt pad placed directly over the site. Injection alone relieves the pain and frequently effects a cure. Forty per cent salicylic acid plasters may be used with caution, but only on patients who are non-diabetic and who have normal vascular systems. If a hard corn is infected or shows a sinus, soothing wet dressings are indicated. A roentgenogram of the phalanx should be taken. The application of 95 per cent phenol or 50 per cent solution of silver nitrate to the sinus often aids in its closure. In the treatment of soft corns conservatism is advised. Surgery may be necessary.

In the treatment of corns, calluses, and warts, marginal felt pads are valuable because they protect the central portion from weight bearing. The application of adhesive pads softens the tissues so that they can be more easily separated from the normal tissues. Zinc oxide circular or oval adhesive pads with thick edges and thin central areas are often helpful. The continuous application of a 10 to 25 per cent salicylic plaster or mull or salicylated collodion paint is effective.

Salicylic acid has long been used to destroy warts. Nitric acid tends to produce keloidal scars. Radium will produce the same results as roentgen-rays in both callus and wart. The orthopædic surgeon and dermatologist should coöperate in the treatment. The most important factors in the prophylaxis and in the treatment of plantar warts are a proper shoe, especially one of good length, pads, heels, bars, and exercises. The warts may be operatively removed, but there is the possibility of a painful scar. After operations the sutures should be allowed to remain until healing is complete.

The "pneumatic" treatment of corns advocated by Unke is an

application of the principle of separation of tissues into layers This tears adhesions and small blood-vessels

The procedure does not remove the primary cause, *i e*, the bony knuckle However, it is probable that the patient by this time has purchased shoes large enough to accommodate the underlying situation

Regardless of whether it cures, it has evidence of merit Novocaine might be preferable Both are absorbed

Soft Corn —"Soft corn" is a painful condition, usually situated in the web between the fourth and fifth toes The keratinous layer of the skin of the web does not have a chance to undergo hypertrophic changes since it constantly becomes macerated and desquamated by the perspiration generated in the deep and poorly drained web between the fourth and fifth toes

Causative Factors

1 Approximation of tissues
2 Generation of heat that cannot radiate
3 Production of moisture that cannot evaporate
4 Irritation by rubbing of tissues over a prominence of bone (a miniature knuckle)

Soft corns are soft because they occur between the toes and are kept moist by perspiration Often intensely painful and, especially to diabetics and patients with vascular disease, dangerous sources of infection, soft corns can be most effectively treated by a simple surgical procedure

Causes

1 Approximation of skin
2 Heat that cannot radiate
3 Moisture that cannot evaporate

Spreading the toes apart corrects all three factors at once

It is a wise precaution not to bind two toes together before inserting some cotton or lamb's wool between them

There is danger of ringworm infestation superimposed upon infection

In most cases, with a change to more roomy footgear, further therapy comprises dissection of the radix of the corn with a special type of curved chisel, a "soft corn spoon," elevation of the head of the fourth metatarsal bone by a foam rubber shield and local application of 50 per cent silver nitrate solution to the pared corn Separation of the involved toes gives relief This is done by inserting a small piece of felt wedge shaped as a duck's bill, a piece of foam rubber or lamb's wool

There may be two complications in the case of soft corn, either of them serious in the presence of diabetes or of disease of the peripheral

circulation. In addition to the usual pain of the corn itself there may be inflammation and swelling extending to the dorsum of the foot. Soft corns may be infected by self paring and careless use of advertised solvents. Drainage and wet dressings are indicated. A sinus may complicate the lesion. It may lead into a dilated sac, which should be opened, curetted and packed, or there may be a sinus extending to the flexor tendon sheath. In some instances a sinus yields to phenol applied to its depth on a fine applicator. In others, complete excision of the sinus is required.

FIG 346.—Beneath soft corn is an exostosis on base of the phalanx of the fourth toe. Through dorsolateral incision excise lateral part of base of this phalanx flush with shaft. If corn is also present on lateral surface of fifth toe, excise head of first phalanx of this toe through dorsomesial incision. Local anesthesia. No splinting. Do not attempt to close joint capsules. Use one or two triple 0 subcutaneous sutures and silk to skin. (J. A. Key operation.)

The treatment indicated includes: 1. Cleanliness and dryness. The corns should be washed frequently with alcohol, dried, and powdered.

2. A round-toe shoe with a metatarsal crescent.

3. Insertion into the shoe of a small felt pad to exert pressure behind the heads of the metatarsal bones.

4. Special exercises to strengthen the supporting structures of the metatarsal arch.

5. The app between the toes of a simple dusting powder such as bi iodide or sulfo-merthiolate two or three times a day.

6 The preparation of a stocking with a stall for the fifth toe like the thumb of a mitten

7 Roentgen-ray or radium therapy

8 Paring down of the horny rim about the center and the application of a corn plaster to protect the corn from pressure The parts should be kept dry by the frequent use of a lotion of salicylic acid, 1 to 3 per cent in 95 per cent alcohol, followed by a dusting powder If the corn has become infected, hot wet dressings of saturated boric acid solution should be applied before treatment of the corn itself is attempted In paring, surgical precautions against infection should be observed Unless pressure on the site of the corn is prevented, the corn will recur

9 The application of concentrated nitric acid or the solid stick nitrate of silver Ochsner applies bichloracetic acid after the surrounding tissues have been protected by vaseline

10 Electric desiccation

11 Operation, consisting of excision of the soft corn and any sinus present, and the removal of a bony spur from the phalanx (See Fig 346) In cases which resist treatment, amputation is indicated

Macey carefully removes the prominent portion of the phalanx because it is often the only method of eliminating the constant etiological factor producing the corn Callus, or corn formation is the result of pressure upon a bony prominence Ideal conditions for such uncommon pressures are found between the fourth and fifth toes

Lapidus stresses the importance of the protuberance of the dorsolateral aspect of the head of the basal phalanx of the fifth toe This projection becomes even more prominent because of the common hammer-toe deformity of this toe This is easily proved by palpating the knuckle A bony protuberance is usually located over the dorsolateral aspect of the proximal interphalangeal joint

The toe-box of the shoe, especially of the short, narrow variety, exerts pressure on the knuckle

A superimposed ringworm infection aggravates the situation The skin becomes cracked and extremely sensitive, opening a portal for infection and sometimes leading to the development of cellulitis of the foot

The Lapidus operation performed under local anesthesia may be an outpatient procedure The skin should be prepared for a few weeks before the operation, if a ringworm infection is present

An incision about 1 5 cm long is made along the dorsal edge of the web The fourth metatarsophalangeal joint is bluntly exposed avoiding injury to digital vessels and nerves The joint capsule is incised and the lateral prominence of the basal phalanx is removed The capsule is closed with one stitch and one or two subcutaneous stitches

are taken in order to obliterate the cavity usually created by the operation. The skin is sutured with a few stitches. The corn itself is not touched during the operation but normally falls off when the stitches are removed. The patient is usually up and about in two or three days wearing a shoe cut out over the fourth and fifth toes.

Neurovascular Corn.—The neurovascular corn is a definite entity. It is usually located under the first or the fifth metatarsal head; at times it may be on the plantar aspect of the big toe or the dorsum of the fifth toe. It is vascularized and intensely painful. Hypertrophied blood-vessels may be seen through the transparent horny layer, lying parallel with the surface and not vertically as in verruca. Close examination may reveal minute superficial fissures. After the corn has been shaved, threadlike nerve elements may be seen interspersed with the blood-vessels. The corn is small, rarely larger than $\frac{3}{16}$ inch in diameter. It occurs in the hyperthyroid person or in the person with thin textured, delicate skin.

Hyperhidrosis—Dyshidrosis—Bromidrosis.—Hyperhidrosis, dyshidrosis, and excessive perspiration of the feet are troublesome conditions. They are most frequent in overweight children and adults who apparently are suffering from a glandular disturbance. The treatment consists in the local applications of a 25 per cent aluminum chloride solution three nights in succession at intervals of about a week. Washing the feet two or three times daily is of value. Chromic acid, 2 gr. to the ounce, may be used as a foot wash, this to be followed by the use of a dusting powder of salicylic acid, 2 gr. in 1 oz. of talcum powder, on the foot and in the hose. For the soft corns that often accompany the conditions under discussion, a bismuth formic iodide powder may be helpful. In certain cases, thyroid and other glandular products are of value. Roentgen-ray therapy is usually successful. Bromidrosis occurs only on the feet.

Ringworm of the Foot.—There are many different kinds of fungus infections of the skin of the feet. The group name for these infections is "myocosis." One of the most common is tinea, commonly known as ringworm, or athlete's foot. It is not confined to the foot nor to athletes. Ringworm of the feet called "epidermophytosis," "trichophytosis" and "athlete's foot," is caused by a plant parasite, or fungus.

The disease is characterized by itching, softening and peeling of the skin between the toes and on the sole of the foot. There are several varieties. In one type the toes become covered with numerous tiny blisters. When the blisters break, fluid escapes and a crust forms. Itching is sometimes intense. Pus may develop in the involved areas, but abscess formation is rare. In quite a few instances a mixed infection with bacteria may occur producing lymphangitis and adenitis.

The nails lose their normal color, develop ridges, and thicken

When ringworm causes an abrasion, ulcer, or a fissure, infects a traumatic wound, or involves the nails, cure may be extremely difficult Many of the persistent cases of ringworm of the feet occur in persons who wear woolen socks The toes furnish a favorable medium because they are warm and moist and the skin surfaces are approximated

Circulatory impairment seems to be a factor favoring the development of the infection in cases of resistant ringworm of the extremities Systemic manifestations of ringworm have been recognized by dermatologists for many years Ringworm parasites have been found in the blood stream Ringworm of the feet is one of the most common diseases of the skin Since World War I its frequency has increased many per cent While the War was of great importance in its dissemination, other influences such as increased attendance at public schools and colleges and increased interest in athletic sports have been contributing factors The incidence of the condition in adults has been estimated at from 70 to 80 per cent According to Gould nine-tenths of the habitués of gymnasiums are infected

In the schools, the infection is least prevalent in the elementary schools, more common in high schools, and most prevalent in the colleges

On examining 3,105 freshmen at the University of California, it was found that 52 3 per cent of the men and 15 3 per cent of the women were infected with ringworm of the feet It has been stated that 70 per cent of senior medical students have the lesion

The diagnosis of ringworm can be confirmed by laboratory methods When scrapings from the lesions are mounted in from 10 to 30 per cent potassium hydroxide and allowed to stand from two to twenty-four hours, the organisms can be readily seen under the microscope

Clippings of infected nails placed in from 15 to 30 per cent sodium hydroxide show a chain of spore-like organisms or skein-like tangle massed threads under the microscope

An extract of the parasite will provoke a positive skin reaction in sensitized persons both on injection into the skin and on the application of a patch

Recurrences are exceedingly common

Treatment —The treatment consists of prophylactic and curative measures and the prevention of reinfection Ringworm should be treated whether it is the only lesion present or whether it occurs concomitantly with other conditions of the foot

Prophylaxis —Ringworm is contracted by direct implantation of the parasite As the growth of the parasite is favored by warmth and dampness, the most common sources of infection are locker rooms, bathroom and shower bath floors, swimming pools, bathing beaches,

and gymnasiums. Other common sources are towels, bath mats, woolen clothes, shoes, stockings, sponges, bandages, and athletic apparatus and goods. Infection may result also from walking barefoot on surfaces that have been walked on with street shoes. Bathroom scales may cause infection if they have been stood upon by persons wearing shoes or by barefooted persons with ringworm of the feet.

Prophylactic measures include strict foot hygiene and the avoidance of barefoot walking. A good plan for persons who frequent club rooms or hotels is to have wooden slippers to keep their feet entirely off the floor. Strict foot hygiene includes frequent bathing of the feet followed by thorough drying; the wearing of clean hosiery and of clean, well-ventilated shoes; and measures to prevent or reduce excessive perspiration of the feet. In addition to barefoot walking, the use of towels and soap used by others and the wearing of hosiery, slippers, and shoes belonging to others, should be avoided.

The practice of inserting one bedroom slipper inside the other is associated with danger because if the sole of the inserted slipper has been contaminated it will infect the other slipper. This statement applies also to the wooden slippers used in the gymnasium.

To prevent the spread of ringworm in the gymnasium of a high school, Gould installed footbaths containing solutions of from 10 to 15 per cent of sodium thiosulfate between the locker and the shower. Each pupil was requested to immerse his feet in the chemical bath on his way from the shower to the locker. The bath was changed after each class of from 30 to 50 pupils. Four weeks after the installation of the thiosulfate baths, the ringworm infection had entirely disappeared. As a substitute for the baths, Gould advised the application of a 20 per cent powder of sodium thiosulfate to the feet, footwear, and floors. This should be applied especially between the toes, around the nails, and inside the socks and shoes. He recommends the combined use of the bath and the powder.

Sterilization of Shoes With Formaldehyde Spray.—Birnbaum's method is simple, effective, inexpensive and readily applicable to large numbers of shoes: An ordinary nasal atomizer is filled with solution of formaldehyde. With the tip of the atomizer well up in the toe of the shoe (the shoe lying on its side) one compression of the atomizer bulb sends a cloud of formaldehyde vapor into the forepart of the shoe. Then the tip of the atomizer is moved to the heel section of the shoe and the bulb is again compressed once, sending another cloud of vapor into the back part of the shoe. The spraying should be performed on three successive nights. Shoes should not be worn during the day. Tests have shown that it required three successive daily sprayings to effect a thorough sterilization. Shoes should not be worn until at least eight hours after spraying. As formaldehyde vapor is irritating to the eyes,

the respiratory tract and the skin, the spraying should be done well away from the face of the operator, in a well-ventilated room, and rubber gloves may be worn When not in use the tip of the atomizer should be sealed with a pin, as this prevents plugging by corrosion

Curative Treatment —For the cure of ringworm infection, cleanliness and dryness of the feet, hosiery, and shoes are essential The shoes should be changed every day, and the stockings at least once a day After each wearing, the stockings should be boiled The shoes should be disinfected by exposing them to sunlight or ultra-violet rays and sprinkling the inside with an antiseptic dusting powder or fumigating them with 40 per cent formaldehyde

Precautions should be taken to prevent spreading of the infection of the feet Towels used on the feet should not be used on other parts of the body In stepping into underwear, great care should be observed as ringworm from the socks, feet, or shoes may be transferred to the groin

The methods of curative treatment of ringworm of the feet include removal of the superficial epithelial layers by mechanical and chemical means, combined with the application of an antiseptic, roentgen-ray and ultra-violet ray treatment, and attempts at desensitization of the skin by the use of special vaccines The infecting organisms may be deep in the skin and are difficult to destroy

Among the chief ointments and other chemical substances used are Whitfield's ointment, salicylic acid in ointment, in lotions, and particularly in alcohol, combinations of sulphur, iodine, and mercury, preparations of tar, ethereal and essential oil, chrysarobin, picric acid, dyes such as mercurochrome, gentian violet, acriflavine, and Castellani's paint[1] which contains acid fuchsin and resorcin

Most cases of chronic ringworm of the toes will respond to 3 per cent salicylic acid and 5 per cent sulfur precipitate in petroleum applied every night or every second night, and a drying astringent dusting powder applied during the day A good powder consists of equal parts of tannic acid, boric acid, and zinc oxide Bismuth, formic iodide or sulfo-merthiolate are very helpful

The use of ultra-violet rays is probably not sufficient for the eradication of ringworm

Roentgen treatment is efficient and safe if administered by an expert Dorne and White obtained good result with the long wave length roentgen rays, called grenz rays

Treatment with the vaccine "trichophytin" to desensitize the skin has yielded favorable results in certain cases of chronic recurrent ringworm The vaccine must be injected intradermally

[1] There is a commercial product called Carbo-Fung, which is satisfactory

In cases of fungus infection of the feet associated with flat-foot, orthopædic corrective measures are important as auxiliary treatment.

Prognosis.—Goeckerman believes that the response to treatment in a given case depends upon: (1) the species or strain of the organism; (2) the sensitiveness of the individual; (3) the degree of moisture; (4) exfoliation; and (5) the patient's general health. Repeated exfoliation finally makes the habitat unfavorable for the infecting organism.

In the opinion of Strickler, Ozellers, and Zalatel, modern dermatological investigation has lifted epidermophytosis from the rôle of a purely local skin disease to that of a skin-sensitizing agent with a probable influence on the life cycle and habits of the skin.

The mosaic fungus is a very common parasite which causes lesions similar to, but not so serious as those produced by the epidermophyton.

The chigger is a parasite which deposits its eggs in the skin and produces intense itching. The sac must be removed and sealed to prevent further trouble.

A migrans parasite which occurs in Florida is more serious than ringworm.

The War and Dermatophytosis.—It is impossible to separate War, marching soldiers, and their feet.

For the sterilization of small numbers of shoes, the following method recommended by Weidman, Emmons, Hopkins and Lewis can be used:

1. Cleanse the shoes of any extraneous débris or dirt. Use any mild soap and water.
2. Dry as well as possible with a dry cloth.
3. Put in each shoe a pad of cotton; spread it out to make an insole.
4. Pour onto this insole (in each shoe) a teaspoon of formaldehyde U.S.P., dilute 1:10.
5. Put the shoes in a paper box, close the lid and wrap in paper. Allow the shoes to remain in this box for at least six hours.
6. Remove them from the box, throw away the cotton and air the shoes for twenty-four hours.
7. Apply saddle or harness soap liberally to all parts of shoes, inside and out. Allow this to dry.

The war has added fresh importance to dermatophytosis.

The incidence of dermatophytosis was found to be high. The hygiene of the feet was paramount both in prophylaxis and in treatment with the emphasis on the detrimental role of sweat. Whitfield's ointment, and also boric acid powder stood up well as fungicide preparations when compared with newer ones like sodium propionate and Cresatin.

The current of opinion is sweeping bacteria into the scene as the cause of many infectious intertrigos that have hitherto been taken for granted as mycotic. Other foot conditions are due to sensitization to local applications such as shoe polish and medicaments, and to long

standing hypostasis and trauma Opinion is swinging to the belief that recurrent attacks represent recurrences the extent to which they are reinfections is probably minor This point bears on prophylaxis by indicating that efforts should be directed at the feet more than the environment Foot baths (hypochlorite and hyposulfite) are becoming discredited

In the sterilization of shoes, sodium propionate, undecylenic acid and Cresatin (metacresylacetate) are useful fungicides

Medicine is now surprised by the theories that Buerger's disease is an allergic expression of dermatophytosis and that little manpower was lost in industry as a result of dermatophytosis

Cutaneous Manifestations of the Fungi Causing Dermatophytosis and Onychomycosis —In the deeper nail infections caused by trichophyton purpureum, treatment is difficult and tedious The removal of the infected portions of the nails must be painstaking For this work a pair of clippers, a scalpel and a small nail chisel are needed

The basic principle of treatment in dermatophytosis of the feet according to Montgomery and Casper, is the use of soothing wet dressings or pastes, during the vesicular stage and of fungicidal remedies after the acute phase has subsided In the case of infections with trichophyton purpureum, strong fungicides must be used In invasions with Monilia albicans, mercurials, silver nitrate or gentian violet are preferred In onychomycosis, it is important to remove all infected nail tissue mechanically before applying fungicides

Dermatophytosis and onychomycosis should be classified according to the etiologic agent rather than by clinical manifestations

Early recognition of the invading fungus and intelligent treatment shorten the duration of the disease

With the great numbers of American soldiers living in tropical climates with their intense humidity, the treatment of fungous disorders of the feet is very difficult Many physicians have adopted the routine use of various dye products, gentian violet and brilliant green for all types of dermatophytosis This is satisfactory in Monilia albicans infection but it will not be curative in the more recalcitrant Trichophyton purpureum *There is no stock prescription for dermatophytosis* All medications revolve on the phases of the infection, whether acute, subacute or chronic, and on the variations of the skin reactions to the fungous toxin One must take the time necessary to curet and shave off the nail from the nail bed A motor driven burr is very helpful In some stubborn cases Lamb uses a paste which is composed of chrysarobin powder mixed in a base of pure saponated solution of cresol which has been saturated with salicylic acid This is applied to the nail bed once every two weeks The skin and periungual areas are protected by a bland salve

Experimentally and also clinically, monilia infections have been

associated with definite riboflavin deficiencies. In some of these cases that do not respond to proper treatment one should add vitamin B complex or riboflavin.

In all nail infections it is most important to remove mechanically as much of the infected portion of the nail as possible. Lamb uses a bur which is most effective; otherwise one can use a scalpel. It is always important to remove the undermined portion of the nail before applying a fungicidal remedy. There is probably a vitamin C deficiency in many cases.

Fungous Infections of the Foot.—The modern habit of wearing shoes that encase the foot has endowed the surface of the foot with the warmth and moisture that makes it an excellent culture medium for the growth of fungi.

Caro finds the treatment of infected nails produces slow improvement. In cases of trychophyton purpureum infestation the prognosis is nearly hopeless. The various remedies used include ointment of benzoic and salicylic acid, 6 per cent salicylic acid and 12 per cent benzoic acid in alcohol, and Castellani's paint. The surface of the nails should be scraped before any medication is applied. Roentgen-rays should be used cautiously. Removal of infected nails of the feet is not curative because the new nails tend to be infected.

Mycetoma.—The only fungous infection involving the deeper tissues that shows a predilection for the foot is mycetoma, or Madura foot.

In recent years fungous infections of the foot have become endemic throughout all parts of the United States. Much progress has been made in the direction of refining methods for the diagnosis of fungous infections and for combating these diseases both by local and by biologic measures. Rapid transportation and the worldwide movements of great masses of men result in a wider distribution of fungous infections that have until now, been limited to isolated sections.

Jamieson and McCrea found organisms in scrapings from the shoes of 40 per cent of patients with ringworm of the feet; the specimens from 25 per cent were definitely not infected, and those from 34 per cent were doubtfully infected.

Pseudomycosis.—Pseudomycosis, described by Castellani in 1928, is characterized by a chronic ulcerative indolent lesion caused by the micrococcus *myceticus, a pleomorphic streptococcus* which at times resembles the staphylococcus and at times the gonococcus. Persons with this condition are prone to develop deformities and contractures. The symptoms are those of an infection with a trench-like ulcer. The original lesion usually occurs below the ankle.

Hamilton recommends ultra-violet lamp treatment and the use of a 1 to 1,500 solution of potassium permanganate and sodium perborate.

I believe that a strip of petrolatum gauze and a plaster cast or even maggot treatment, would be better Surgery should be avoided if possible

Psoriasis —Psoriasis of the skin and nails is an interesting lesion occasionally seen in persons with atrophic arthritis

Scleroderma —Scleroderma causes the skin to become unusually thin and tight Its cause is unknown but by some the condition is attributed to a glandular disturbance It may or may not be associated with arthritis The prodromal pain and stiffness of the joints of the feet may persist or increase Vasomotor and trophic disturbances are frequent In sclerodactylia, the symptoms resemble those of Raynaud's disease In the generalized form, there may be prodromal symptoms such as occur in Raynaud's disease, *viz*, weakness, sensory disturbances, loss of weight, and pain in the joints

The diffuse form of scleroderma may begin with arthralgia, malaise, loss of weight, and asthenia, or with vasomotor phenomena in the extremities similar to those associated with Raynaud's disease O'Leary reported a series of 48 cases of generalized and 55 cases of circumscribed scleroderma In more than one-half of the cases of the generalized type, arthritis preceded or occurred simultaneously with the development of the scleroderma In 33 per cent, the onset was preceded by varying degrees of vasomotor disease in the extremities Sclerodactylia was observed in 89 per cent

Erysipelas of the Foot and Ankle —Erysipelas is characterized by tenderness, redness, elevation and thickness of skin accompanied by systemic manifestations of fever, toxemia, and leukocytosis Of chief orthopædic interest is the postoperative variety which must be differentiated from acute osteomyelitis

Ude and Platow made a comprehensive analysis of 402 cases of erysipelas in a hospital The methods of treatment were as follows magnesium sulfate and glycerin packs, roentgen irradiation, ultra-violet irradiation, erysipelas antitoxin, roentgen irradiation and antitoxin, and ultra-violet irradiation and antitoxin The newer methods of treatment reduced the mortality approximately 44 per cent Roentgen or ultra-violet irradiation, were highly efficacious The temperature returned to normal and the symptoms subsided from three to four days earlier than in cases treated by the magnesium sulfate and glycerin-pack method Of the cases treated by ultra-violet irradiation, a clinical arrest of the disease followed the first treatment in 92 per cent

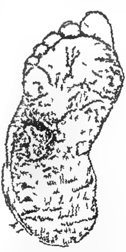


FIG 347 — Ulcer of plantar surface in patient who had spina bifida (Redrawn from photograph)

The results obtained by either form of irradiation and by antitoxin were approximately the same, but were slightly more favorable in the cases treated with the ultra-violet rays. Ude and Platow regard ultra-violet irradiation as a universally applicable method.

At Bellevue Hospital, New York, over 2,500 patients with erysipelas were treated by the intramuscular injection of erysipelas-streptococcus antitoxin in a period of four years. The effect was often dramatic. Failure to obtain any benefit was relatively rare. The earlier the administration of serum the more prompt and certain the recovery. The average patient requires only 2 or 3 doses. In some cases, one therapeutic dose is sufficient.

In 13 cases, Abdel Saye injected a milk barrier near the site of the infection with excellent results. Fresh milk was boiled for four minutes and then cooled and strained through sterile gauze. The amount injected varied from 5 to 15 cc. As much as possible was injected intradermally, the remainder subcutaneously. A long fine needle was introduced parallel with the spreading margin and about 1½ inches from it. The injection was made at intervals along the line.

Furunculosis and Other Skin Conditions.—Furunculosis of the skin of the foot should be treated by local applications of boric acid, elevation, fomentations, and when necessary, surgery. Brewer's yeast is of value. Sulfapyridine is recommended.

Numerous cases of erysipeloid eruption of the skin of the feet due to fungi have been reported. Insect bites of the feet may result in serious infection.

In cases of chronic streptococcic ulcer, Goodman obtained excellent results from the use of sulfanilamide. Penicillin is better.

Ulcers of the Foot and Ankle.—The types of ulcers are traumatic, infectious, fungoid, circulatory, neurogenic and diabetic. (See Chapter on Peripheral Vascular Lesions.)

Excessive Treatment Dermatitis—The Cure Is Worse Than the Disease.—In deploring the "unbelievable chemical abuse" to which the human foot is subjected, Underwood and Gaul relate that they see patients daily who have used dozens of remedies for their conditions. In a word their plaint is that dermatitis is resulting all too frequently from overtreatment with the dozens of commercial preparations now on the market for athlete's foot or itching skin.

According to these writers mercuric compounds were the most frequent cause of dermatitis and phenol and ethyl aminobenzoate were runners-up. They also question the use of therapeutic tars. They recommend that all compounds containing mercurials carry a "warning" on the label of the presence of a "sensitizer."

Individuals who exhibit a rash between the toes are probably victims of ringworm infection. Many try home remedies. When they

fail the patient is likely to consult a physician. By this time the original disorder has undergone many changes. A careful study of the lesions at this stage may not disclose the fungus. In some, the various antiseptics and salves which had been applied may be the cause of the dermatitis.

This annoyance is seen in persons in all walks of life. According to Van Dellen the organism is more likely to attack when the ordinary rules of foot hygiene are relaxed. Although the infection is more prevalent during hot weather, it may develop at any time in those whose feet become warm and moist, particularly following exercise. Heavy and poorly ventilated shoes also may contribute to overheating.

Recurrences are common, but it is difficult to ascertain whether this is due to a new invasion or to the fact that the initial infection was not cured. Some of the fungus organisms may remain in the nails, others continue to grow in shoes, clothing or floors.

Much can be done to minimize a second attack if certain precautions are observed. First and foremost is to keep the feet clean and dry, with special attention to the toes. Whenever possible, light shoes should be selected. When they are not being worn, exposing the feet to sunlight and air is recommended. Dusting the feet with a powder containing 10 per cent boric acid, morning and night, is advised. This helps to absorb excess moisture. Walking barefooted in showers, locker rooms, or any damp quarters should be avoided. Too much reliance cannot be placed on foot baths.

Numerous remedies have been suggested for treatment but, unfortunately, the success of one solution does not mean that the same results will be obtained in all sufferers. Extreme caution must be exercised in accepting some one's "pet" remedy. It may be too strong during one phase, or too weak during another. It is wise to try simple preparations, such as boric acid powder or a dilute solution of potassium permanganate. Shoes must not be overlooked and by utilizing formaldehyde, sterilization is possible.

Research during the war has produced a new preparation—undecylenic acid-zinc undecylenate mixture. The Navy surgeons report spectacular results in a large series of cases in the prevention and treatment of athlete's foot. The powder and ointment forms were employed, but the powder was preferred because of its convenience. In this study, the incidence of infection was reduced from 28 per cent among those using no prophylaxis, to 4 per cent in the trainees who dusted the new formula on the feet.

In the Pacific theatre of war, fungus infections at some tropical bases have been responsible according to Jordan for as many as 3 out of 4 of all clinic or sick bay calls. The feet (especially between the toes), groin and scalp are favorite locations. The first sign of infection

The results obtained by either form of irradiation and by antitoxin were approximately the same, but were slightly more favorable in the cases treated with the ultra-violet rays. Ude and Platow regard ultra-violet irradiation as a universally applicable method.

At Bellevue Hospital, New York, over 2,500 patients with erysipelas were treated by the intramuscular injection of erysipelas-streptococcus antitoxin in a period of four years. The effect was often dramatic. Failure to obtain any benefit was relatively rare. The earlier the administration of serum the more prompt and certain the recovery. The average patient requires only 2 or 3 doses. In some cases, one therapeutic dose is sufficient.

In 13 cases, Abdel Saye injected a milk barrier near the site of the infection with excellent results. Fresh milk was boiled for four minutes and then cooled and strained through sterile gauze. The amount injected varied from 5 to 15 cc. As much as possible was injected intradermally, the remainder subcutaneously. A long fine needle was introduced parallel with the spreading margin and about 1½ inches from it. The injection was made at intervals along the line.

Furunculosis and Other Skin Conditions.—Furunculosis of the skin of the foot should be treated by local applications of boric acid, elevation, fomentations, and when necessary, surgery. Brewer's yeast is of value. Sulfapyridine is recommended.

Numerous cases of erysipeloid eruption of the skin of the feet due to fungi have been reported. Insect bites of the feet may result in serious infection.

In cases of chronic streptococcic ulcer, Goodman obtained excellent results from the use of sulfanilamide. Penicillin is better.

Ulcers of the Foot and Ankle.—The types of ulcers are traumatic, infectious, fungoid, circulatory, neurogenic and diabetic. (See Chapter on Peripheral Vascular Lesions.)

Excessive Treatment Dermatitis—The Cure Is Worse Than the Disease.—In deploring the "unbelievable chemical abuse" to which the human foot is subjected, Underwood and Gaul relate that they see patients daily who have used dozens of remedies for their conditions. In a word their plaint is that dermatitis is resulting all too frequently from overtreatment with the dozens of commercial preparations now on the market for athlete's foot or itching skin.

According to these writers mercuric compounds were the most frequent cause of dermatitis and phenol and ethyl aminobenzoate were runners-up. They also question the use of therapeutic tars. They recommend that all compounds containing mercurials carry a "warning" on the label of the presence of a "sensitizer."

Individuals who exhibit a rash between the toes are probably victims of ringworm infection. Many try home remedies. When they

fail the patient is likely to consult a physician By this time the original disorder has undergone many changes A careful study of the lesions at this stage may not disclose the fungus In some, the various antiseptics and salves which had been applied may be the cause of the dermatitis

This annoyance is seen in persons in all walks of life According to Van Dellen the organism is more likely to attack when the ordinary rules of foot hygiene are relaxed Although the infection is more prevalent during hot weather, it may develop at any time in those whose feet become warm and moist, particularly following exercise Heavy and poorly ventilated shoes also may contribute to overheating

Recurrences are common, but it is difficult to ascertain whether this is due to a new invasion or to the fact that the initial infection was not cured Some of the fungus organisms may remain in the nails, others continue to grow in shoes, clothing or floors

Much can be done to minimize a second attack if certain precautions are observed First and foremost is to keep the feet clean and dry, with special attention to the toes Whenever possible, light shoes should be selected When they are not being worn, exposing the feet to sunlight and air is recommended Dusting the feet with a powder containing 10 per cent boric acid, morning and night, is advised This helps to absorb excess moisture Walking barefooted in showers, locker rooms, or any damp quarters should be avoided Too much reliance cannot be placed on foot baths

Numerous remedies have been suggested for treatment but, unfortunately, the success of one solution does not mean that the same results will be obtained in all sufferers Extreme caution must be exercised in accepting some one's "pet" remedy It may be too strong during one phase, or too weak during another It is wise to try simple preparations, such as boric acid powder or a dilute solution of potassium permanganate Shoes must not be overlooked and by utilizing formaldehyde, sterilization is possible

Research during the war has produced a new preparation—undecylenic acid-zinc undecylenate mixture The Navy surgeons report spectacular results in a large series of cases in the prevention and treatment of athlete's foot The powder and ointment forms were employed, but the powder was preferred because of its convenience In this study, the incidence of infection was reduced from 28 per cent among those using no prophylaxis, to 4 per cent in the trainees who dusted the new formula on the feet

In the Pacific theatre of war, fungus infections at some tropical bases have been responsible according to Jordan for as many as 3 out of 4 of all clinic or sick bay calls The feet (especially between the toes), groin and scalp are favorite locations The first sign of infection

Ingrown Toenails.—An ingrown toenail is one in which one or both lateral margins are embedded in the soft tissues of the nail groove producing inflammation. It is very common to find that the lateral margins of the nail protrude like a spatula.

The edge of the nail digs into the soft tissues, and forms a saw-tooth cutting edge, which produces a callus, warty growth, fissure and infection.

The chief causes are short and pointed shoes, high heels, short or tight stockings, and improper trimming of the nails, *i. e.*, trimming of the corners.

Of Keys' series of patients with ingrown nails, three-fourths were women. Obvious causes of the condition were tight shoes and high heels thrusting the body weight forward and down into the toes. Contributory causes were obesity, pregnancy, and occupations involving much walking. However, the toes of many of the patients were observed to be unusually wide and to have thickened nails. The best treatment for ingrown toenails is its prevention by proper shoes. When a nail shows a tendency to dig into the skin margin, it may be compelled to grow above the margin by inserting under its edge, by means of a blunt toothpick, a wisp of cotton saturated with a drop of castor oil. A good ointment is described on page 725.

Operation may be partial or radical. With the use of a constrictor around the root or base of the big toe and under local anesthesia, an incision is made which excises the entire inflamed area of the skin. (Fig. 348.)

Infected ingrown toenails should be treated by rest, elevation, and hot fomentations for a few days before they are operated upon. Irradiation hastens recovery.

A serious lymphangitis may follow infected ingrown nails.

LEGEND FOR FIG 348

FIG 348.—1, After thorough sterilization of the field and placing of the tourniquet, a cutaneous wheal is raised over the outer side at the base with a 1 per cent novocain solution 2, The needle is then inserted through the superficial wheal and deep infiltration is made. In doing this, it is a good plan to inject part of the solution, withdraw the needle point almost to the skin surface, and reinsert it at a slightly different angle In this way the entire area at the medial side of the bone is anesthetized. 3, The same procedure of injections is repeated on the inner aspect of the toe The phalangeal nerves course distally, one to each side of the bone. By this method the general region through which these nerves pass is infiltrated and a block established at the base of the toe. 4, Long incision. 5, A semicircular incision is made, excising a wedge-shaped piece of tissue which includes the offending part of the nail, together with its matrix and eponychium The excision should be thorough to prevent any new formation of nail The cross-section of toe illustrates wedge of nail and tissue to be removed 6, In this less radical procedure, a flap is dissected back. The freed portion of the nail is grasped by a clamp and avulsed Then the nail bed is thoroughly curetted or excised 7, When the cavity is large a single black silk suture may be placed as illustrated and the remainder of the cavity packed with vaseline gauze. (Courtesy of the Winthrop Chemical Company.)

Injuries to Toenails —*Injury* is evidenced by subungual hemorrhage which is treated by drilling and evacuation of the hematoma

The impact of a heavy object on a toenail frequently injures the nail bed In many cases of such injury the original nail fails to grow but there is a second nail underneath, which eventually crowds off the original nail

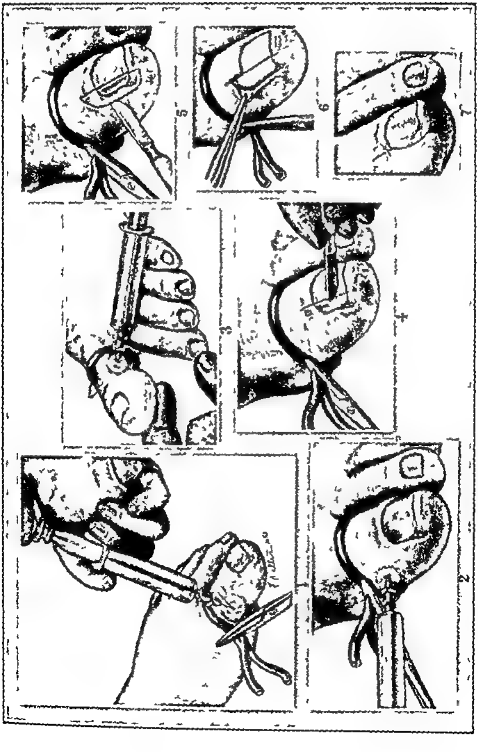


Fig 318

Changes in Color.—Redness of the nail bed in children indicates shortness of the shoes, especially if there is tenderness when backward pressure is exerted on the end of the nail.

Loss of translucence of the nails may be secondary to anemia, chlorosis, angiospasm, polycythemia, icterus, or pigmentary disease, all of which can be easily recognized. It may be due also to thickening of the nail plate or an increase of the subungual horny layer. As in some cases a growth of monilia or other fungus may be responsible, scrapings from under the free border of the nail should be examined in a solution of potassium hydroxide or cultures on Sabouraud's maltose agar should be made.

A change in the color of the nail is seen frequently after treatment of infections or injuries about the nails, with mercury solutions or white precipitate ointment. It is due to impregnation of the nail with mercuric sulfate, which seems to be precipitated by light.

Addison's disease and hyperthyroidism cause a change in the color of the nails. Rarely, psoriasis is first manifested by a discoloration of the nails with thickening followed by thimble-like pitting, cross-furrows, irregular depressions, or partial separation of the nails at the free border or the sides.

Brittle Toenails.—Brittle toenails can be benefited by local applications of an ointment or an oil, but their cause may be a glandular or vitamin deficiency or a circulatory disturbance. Toenails are easily molded by firmer tissues and shoes.

The eggshell nail is a thin white nail with a purplish tinge, which is uptilted at the free border. It is part of the picture of erythrocyanosis of the extremities associated with hyperhidrosis, the whole probably dependent upon some disturbance of the endocrine glands. It is seen most frequently in young girls.

Onychia (Onychitis).—Onychia is due to inflammation of the matrix or foldsof the nail. Trauma, pyogenic microörganisms, foreign bodies beneath or within the nail-plate, or parasites may excite inflammation of the soft parts about the nail sufficient to produce distortion, separation of the plate, ulceration, and even digital gangrene.

Hangnails.—Hangnails are tags of the lateral nail-folds that become detached and torn. At times the rift penetrates deeply into the sulcus at the side of the nail, providing an atrium for infection. This may be the first step toward the production of a serious onychia terminating in exfoliation of the distal phalanx.

Paronychia.—Paronychia is an infection of the edge of the nail frequently originating in a hangnail. There are two main types. The *acute* type gives rise to a painful, but small abscess on the sub-epithelial tissue at the edge of the nail, which if opened, terminates the process. If neglected, the pus spreads to the back of the nail giving rise to the

second type or *typical* paronychia For several days pus will exude from the inflamed nail edge Swelling and redness are present, but little or no pain A week or two later the entire nail will be detached from its matrix and can be lifted off Aside from the suppurating bacteria, paronychia may be caused by fungi The treatment consists in allowing the pus to escape This is shown in Figure 350

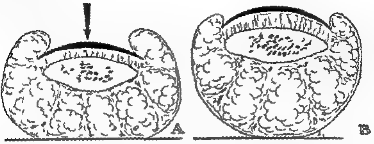


FIG 349 —Transverse sections through the terminal phalanx of the great toe In the drawing on the left the effect of the downward pressure of the bone in producing an in growing toenail is shown Note especially the intimate attachments of the nail to the bone and the arrangement of the fibro-fatty loculi under the terminal phalanges of the toes (Redrawn from Norman C Lake, courtesy of Baillière Tindall & Cox)

Onychauxis —The term "onychauxis" means hypertrophy of the nail The nails may be increased in length, breadth, or thickness, and changed in shape, density, color or texture The term "onychogryphosis" is applied to a twisting distortion of the nails In this condition the nail, particularly that of the great toe, is claw-like or twisted like a horn There is marked thickening due to hyperkeratosis of the nail-bed The nail plate may be increased in any dimension The nails are dull, opaque, yellowish-brown or black, and often ridged, rugose, or furrowed The *subungual space contains poorly formed* corneous material which may become secondarily infected The subungual horny deposit may raise the distal end of the nail from its bed

Ringworm Fungi —Ringworm fungi very commonly affect the nails and cause them to become brittle, granular, overgrown, warty, and crumbly

In ringworm of nail Scott tells me his best results follow the routine of

1 *Application of Castellani s paint one night and*
2 Glycerine the next, until cured

Dystrophies of the Toenails —Dystrophies of the toenails, many of which are due to ringworm, should be treated by a dermatologist Some of them are due to circulatory insufficiency For hereditary dystrophy of the nails roentgen-ray and thyroid extract have been recommended

Hyperkeratosis —The author has cut some hardened overgrown nails that required the use of bone-biting rongeur forceps When I attended Northwestern University Medical School Dispensary in 1915,

a woman seventy-five years of age came in and requested to have her nails cut. We were a little bit insulted at first, but when we looked at the toenails we found it was impossible for anyone to cut them without such instruments as the emery wheel, a bone-biting rongeur, or a bone saw.

"Snail Nail."—This is the term applied to a nail with the shape, color, and appearance of a snail. It is most common on the great toe.

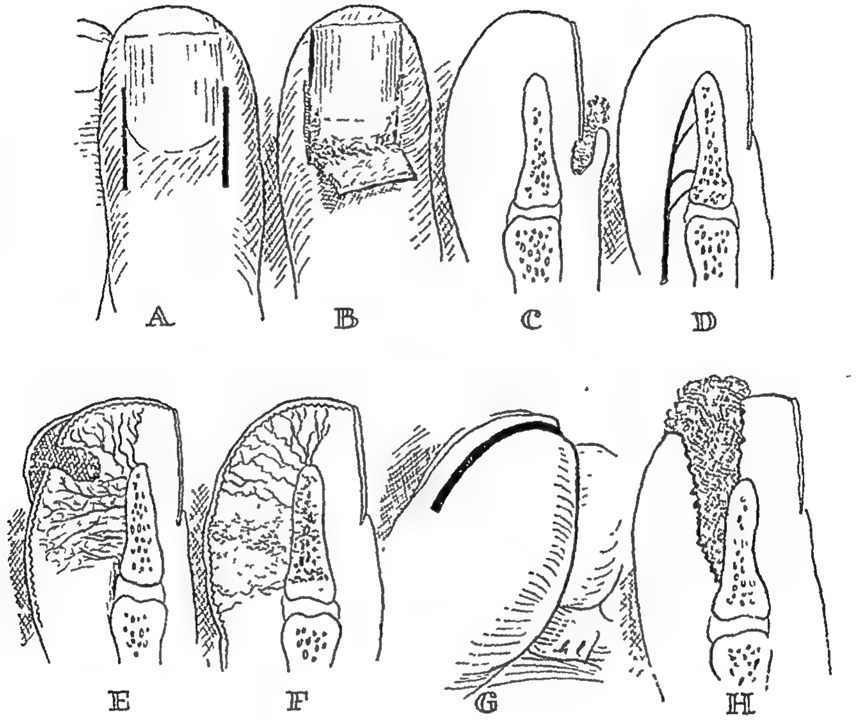


FIG 350 —*A*, Paronychia. Sites of incisions to avoid injury to cuticle and matrix. *B*, Paronychia Exposure of nail root Area proximal to dotted line to be removed. *C*, Paronychia. Gauze pack in place *D*, Blood supply to epiphysis and diaphysis. Note epiphyseal branch does not traverse anterior closed space. *E*, Typical collar-button abscess *F*, Mode of invasion and involvement of phalanx. *G*, So-called fish-mouth incision (about two-thirds shown). *H*, Method of establishing bone drainage without dealing directly with bone Gauze pack in place (Redrawn from sketch of similar lesion of the fingers)

(Fig. 351.) It is treated by removal of the nail and excision or destruction of the nail bed. For the removal of the nail my bunion dissector is excellent. "Spikes" should be avoided.

I removed two toenails that were 2 inches long and shaped like elephant tusks or ram's horns.

Onychogryphosis, or Ram's Horn Nail.—Onychogryphosis is produced by a discrepancy in growth between the distal and proximal portions of the nail. The treatment is removal of the nail.

The following lesions are the most common seen under the nails.

Subungual hemorrhage is responsible for many cases of shedding of the nail. In some instances the hemorrhages are microscopic. In

others, minute reddish black specks become visible beneath the plate In extreme cases the entire matrix becomes black from effused blood

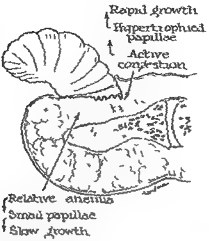


FIG 351 —A ram's horn nail onychogryphosis treated by onychotomy or removal of nail (Redrawn from Norman C Lake courtesy of Bailliere Tindall & Cox)

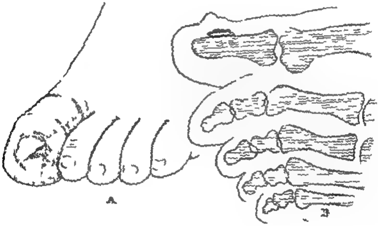


FIG 352 —Subungual exostosis *A* From photograph *B* From roentgenogram

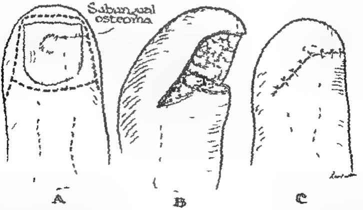


FIG 353 —A plastic operation for complete and permanent removal of the toenail is described This operation is offered for cases of onychogryphosis subungual osteoma and deformity of the toenail where complete removal of the nail is indicated (Lapidus courtesy of Am Jour Surg)

When the process separates the plate from the bed, the nail is shed. Subungual hemorrhages occur after trauma, in scurvy, in hemophilia, and in certain disorders of the circulatory and nervous systems. Removal of the nail plate may be necessary.

Subungual warts are due to pressure and should be operated upon. The pressure may be due to a knuckle of bone. Subungual exostoses are removed by surgery. Injuries to the nail or its bed cause irregular growth of the nail, pressure, and deformities.

Warts are prone to develop in areas that are kept moist and warm. The use of dusting powders of various kinds, cleansing applications, and ointments sometimes helps.

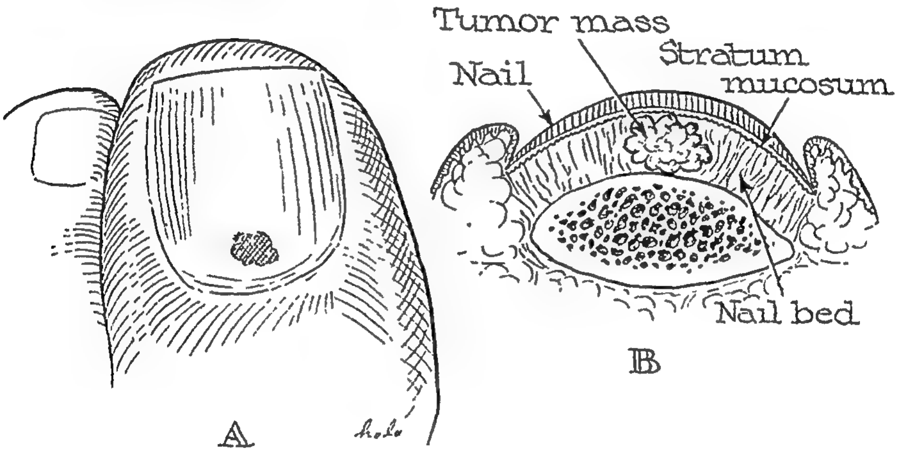


FIG 354.—Granuloma of nail bed. *A*, Site of granuloma in nail bed. *B*, Cross-section

Radium and roentgen therapy is usually successful, but some warts are resistant. If the wart has not entirely disappeared after six weeks of moderate irradiation, surgery is advised. A skin graft may be necessary.

The recurrence of warts is almost certain unless proper shoes are worn. It is advisable to modify the shoes externally and internally.

Subungual tumor-formation may occur. Shepard reported a subungual chondroma; Hutchinson an epithelioma; and Kraske, a sarcoma. I have seen a number of corns growing beneath the nail-plates. Heller gives details of other subungual tumors, including papilloma, fibroma, leiomyoma, endothelioma, angioma, and angiosarcoma. Telangiectases have also been noted.

Partial Destruction of Toenail Bed.—Failure of the distal half of a toenail to adhere to the underlying tissues may be due to injury and partial destruction of the nail bed. As a result of such injury this portion of the nail bed does not function in a normal manner and does not take part in the formation of the growing nail.

The following prescription makes a satisfactory ointment for ingrowing toenail edges and should be applied only to the excessive callus in the nail groove

℞	Camphorae			
	Chloralis hydratis	āā		33
	Acidi salicylici		7	5
	Lanolin			
	Cerati	āā q s ad	30	

M et ft ung
Sig Externally as directed

When the process separates the plate from the bed, the nail is shed. Subungual hemorrhages occur after trauma, in scurvy, in hemophilia, and in certain disorders of the circulatory and nervous systems. Removal of the nail plate may be necessary.

Subungual warts are due to pressure and should be operated upon. The pressure may be due to a knuckle of bone. Subungual exostoses are removed by surgery. Injuries to the nail or its bed cause irregular growth of the nail, pressure, and deformities.

Warts are prone to develop in areas that are kept moist and warm. The use of dusting powders of various kinds, cleansing applications, and ointments sometimes helps.

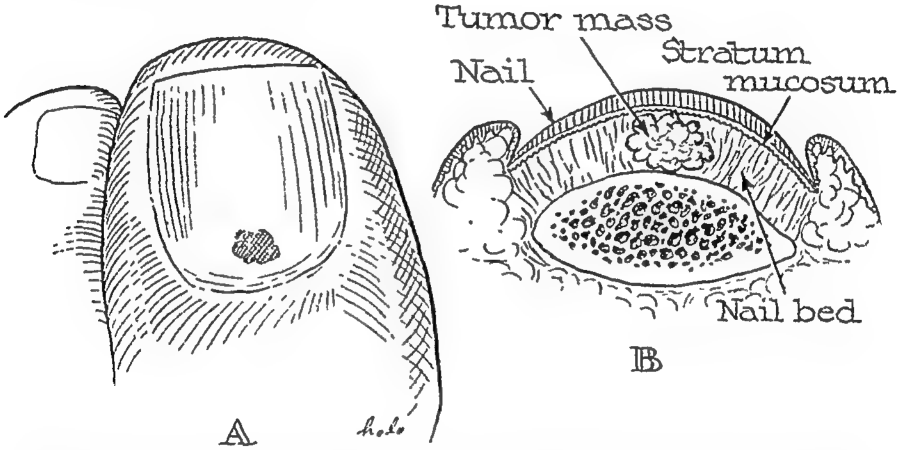


FIG 354 —Granuloma of nail bed. *A*, Site of granuloma in nail bed. *B*, Cross-section.

Radium and roentgen therapy is usually successful, but some warts are resistant. If the wart has not entirely disappeared after six weeks of moderate irradiation, surgery is advised. A skin graft may be necessary.

The recurrence of warts is almost certain unless proper shoes are worn. It is advisable to modify the shoes externally and internally.

Subungual tumor-formation may occur. Shepard reported a subungual chondroma; Hutchinson an epithelioma; and Kraske, a sarcoma. I have seen a number of corns growing beneath the nail-plates. Heller gives details of other subungual tumors, including papilloma, fibroma, leiomyoma, endothelioma, angioma, and angiosarcoma. Telangiectases have also been noted.

Partial Destruction of Toenail Bed.—Failure of the distal half of a toenail to adhere to the underlying tissues may be due to injury and partial destruction of the nail bed. As a result of such injury this portion of the nail bed does not function in a normal manner and does not take part in the formation of the growing nail.

The following prescription makes a satisfactory ointment for ingrowing toenail edges and should be applied only to the excessive callus in the nail groove

℞ Camphoræ			
Chloralis hydratis	āā		33
Acidi salicylici		7	5
Lanolini			
Cerati āā q s ad		30	

M et ft ung

Sig Externally as directed

When the process separates the plate from the bed, the nail is shed. Subungual hemorrhages occur after trauma, in scurvy, in hemophilia, and in certain disorders of the circulatory and nervous systems. Removal of the nail plate may be necessary.

Subungual warts are due to pressure and should be operated upon. The pressure may be due to a knuckle of bone. Subungual exostoses are removed by surgery. Injuries to the nail or its bed cause irregular growth of the nail, pressure, and deformities.

Warts are prone to develop in areas that are kept moist and warm. The use of dusting powders of various kinds, cleansing applications, and ointments sometimes helps.

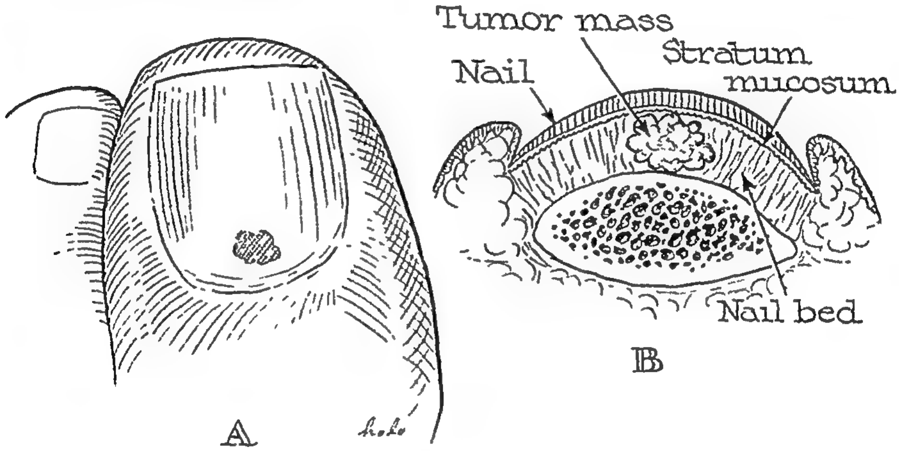


FIG 354 —Granuloma of nail bed *A*, Site of granuloma in nail bed. *B*, Cross-section

Radium and roentgen therapy is usually successful, but some warts are resistant. If the wart has not entirely disappeared after six weeks of moderate irradiation, surgery is advised. A skin graft may be necessary.

The recurrence of warts is almost certain unless proper shoes are worn. It is advisable to modify the shoes externally and internally.

Subungual tumor-formation may occur. Shepard reported a subungual chondroma; Hutchinson an epithelioma; and Kraske, a sarcoma. I have seen a number of corns growing beneath the nail-plates. Heller gives details of other subungual tumors, including papilloma, fibroma, leiomyoma, endothelioma, angioma, and angiosarcoma. Telangiectases have also been noted.

Partial Destruction of Toenail Bed.—Failure of the distal half of a toenail to adhere to the underlying tissues may be due to injury and partial destruction of the nail bed. As a result of such injury this portion of the nail bed does not function in a normal manner and does not take part in the formation of the growing nail.

The following prescription makes a satisfactory ointment for ingrowing toenail edges and should be applied only to the excessive callus in the nail groove

℞ Camphoræ			
Chloralis hydratis	āā		3 3
Acidi salicylici		7	5
Lanolin			
Cerati āā q. s. ad		30	

M. et ft. ung.
Sig. Externally as directed

CHAPTER XXXIII

FOOT HYGIENE AND SANITATION—"MINOR" CARE OF THE FEET

Foot hygiene and sanitation are especially important because this member is the one portion of the body that is heavily and rigidly covered practically during most of the waking hours. It is almost constantly in action, perspiring and kept warm.

Minor care of the feet includes hygienic measures such as frequent bathing, the use of dusting powders, and the wearing of shoes and hosiery which allow sufficient ventilation of the feet; proper trimming of the toenails; the prevention of irritation and of circulatory and mechanical disturbances by the wearing of proper garters, shoes, and hosiery; and the treatment of diseases of the skin and of diseases and deformities of the toenails.

Daily bathing of the feet is important. Dusting powders should be simple and non-irritating.

The *toenails should be trimmed at regular intervals, the length* of which depends upon their rate of growth. Some nails require trimming every two weeks, whereas others may grow for six or more weeks without becoming too long to cause trouble. Except in the case of the ballet dancer, who is usually obliged to trim her nails along the edges in order to insure comfort when she is on her toes, the trimming should be done straight across.

Any person who becomes conscious of his feet should have the matter investigated promptly. It is a good plan to wear new shoes one hour three times a day for a few days.

The harmful effects of poor shoe fitting are widespread.

There is a difference between: (1) ideal footwear, (2) appropriate footwear, (3) corrective footwear.

Factors involved are: (1) fit, (2) shape, (3) style.

Shoe Construction Factors	
1 Length	5. Straight inner line
2 Width	6. Toe room
3. Waist snug	7. Heel grip
4. Shank	8. Lining

The organization of the shoe industry is complex. Competitive conditions in the industry and the influence of styling have served to inhibit coöperative action on this problem.

Shoes can do harm to the feet if they do not fit properly and thus impair the efficiency and earning capacity of a person

Scientific research on new methods of foot measurement adapted to the study of a large, representative sample of the population and capable of producing uniform results that can be analyzed by statistical procedures, is a requisite to developing new size standards Successful development of national standards for sizing and fitting shoes depends upon the cooperative efforts of all the persons concerned working together through the procedures of a national standards agency

The provision of proper shoes is of major importance One of the most difficult situations is the elderly woman with arthritis, who practically never finds shoes that fit her feet She walks badly, thereby increasing the stress and strain on her hips and back Her feet suffer not only from arthritis, but also from the wear and tear of the superstructure Her knees suffer

It is a common sight in orthopedic clinics to see a young woman with big callouses on the soles of her feet and corns on her clawed toes, all due to wearing shoes that are too short and too tight

The weight of the shoe is rarely an important consideration This is true in young children where a sturdy shoe is desirable The child walks on the same surfaces as its parents or nurse and deserves the same type of protection

The harmful effects of shoe fitting will supply the orthopedic surgeons of the country with "foot cases" for many years to come

Short shoes on growing children constitute a serious problem

Many adolescents and young children have flat feet which have never been given consideration because they did not cause pain Children should be provided with shoes that are made of sturdy leather and which fit properly Many growing children wear shoes for too long a time so that the feet are injured because of the reluctance or poverty of the parents to buy new shoes as often as they are needed

The Myth of the Corrective Shoe —Is there such a thing as a corrective shoe?

What do we accomplish by corrective shoes? Temporarily relief

We restore normal alignment and relations of the key, static or architectural structures so that the dynamic forces may operate normally to correct a mechanical, static or dynamic defect This means that active exercises are the key to cure or correction

To the purchaser of shoes I would say

1 Use a shoe horn to put on oxfords

2 Avoid using your index finger for a shoe horn because the compression produced thereby may cause injury to the delicate joint structures, which may be followed by arthritis producing Heberden's nodes, enlargements of the finger-end joints (Swaim)

3. Do not expect a short or narrow shoe to become comfortable.
4. Do not compel your feet to "break in" a new pair of misfit shoes.

Bedroom slippers should have heels. "Gym" shoes, sneakers, Keds, and crepe-soled and heavy rubber-soled shoes are permissible only for gymnastic work. They may have pads inserted to support the arches. The foot complaints which are common in boys and girls returning from summer camps are due most frequently to improper shoes and the change from country roads to city pavements.

Cushion pads enhance the supportive elements in the construction of the shoe, minimize irregularities, and cushion the step.

Newer Types of Shoes for Girls and Women.—*Cut-out toes give the* big toe extra room if the cut-out is placed properly. If it is in the middle of the shoe it inclines the big toe into a valgus position.

Counterless.—Counterless shoes are bad.

Wedgies.—The higher ones are better than lower because the former hug the longitudinal arch during walking.

Loafers.—These furnish no support.

Ballets without heel. These have no metal for support.

I have no quarrel with the newer styles, but some are harmful, especially counterless, ballets and loafers. I have yet to see one girl walking in counterless shoes, whose heels were not in valgus. Counterless shoes favor swelling of the feet. Young girls cannot go wabbling around on high heels all day without getting into trouble sooner or later.

If a person has good feet and wears good shoes as a rule, it will do no harm to wear less desirable shoes for short periods on festive occasions.

Care of Shoes.—A person should take good care of his shoes if he wants them to take good care of his feet.

Oiling of shoes is not a general proposition. It is important in certain occupations where shoes get wet, in certain sports such as hunting and in military personnel.

The retention of the shape of the shoes is a matter that pays dividends. One should prevent his shoes from becoming out of shape. This produces wrinkles and other harmful effects especially on the toes.

Lacing of Shoes.—Before the lacing of a shoe is begun, the shoe should be completely on and the tongue pulled taut. To prevent the lace from loosening up, many athletes pass it twice through the middle eyelets. When loose lacing of the top eyelets is desired, spreading of the top of the shoe may be prevented by passing the lace twice through the next lower eyelets.

Extra laces are a good investment. The harmful effects of poor lacing are evidenced by irritation and interference with local circula-

tion Laces may assume a see-saw action, like a saw, producing a saw-like irritation

Golf—Shoe laces may cause irritation of the dorsum of the foot producing phlebitis or synovitis of joints and bursae Veins are vulnerable to pressure because they are not padded One of my patients, a dentist, who was a good golfer bought new shoes which produced phlebitis in a few days When short laces are pulled tightly to tie a bow, they constrict and irritate

HOSIERY

Stockings are made of cotton, wool, silk, and synthetic materials such as rayon and nylon The stockingless fad may be beneficial to the legs and general health, but may harm the feet Proper stockings protect the feet The importance of the correct size and looseness of hosiery should be emphasized It has been stated that, like shoes, stockings should always be worn on the same foot This can be accomplished by having right and left stockings or by putting a mark such as a red thread, through the right stocking of each pair In some cases digitated stockings are advisable To prevent irritation from knots, stockings may be worn inside out Stockings have an important action on the skin and on the blood-vessels, especially the veins Some of them produce heat and prevent the evaporation of perspiration Woolen stockings favor the growth of ringworm organisms In the cases of children, one must beware of stockings that are too tight or too loose, and those with reduplication

Nylon —Some women cannot tolerate nylon hose because it produces a burning sensation in the skin, and even a rash

Elastic Stockings —These can be worn in cases of moderate edema, usually from varicose veins They make the limbs feel and act younger and eliminate the feeling of dragging a ball and chain They should be worn every minute the person is on his feet

Garters —Garters should not interfere with the circulation

THE CARE OF MINOR AILMENTS OF THE FOOT AND ANKLE IN MILITARY SERVICE

One of the most important subjects of every military service is the matter of feet During my service at Camp Blanding as commanding officer of the 16th Evacuation Hospital I formulated the following recommendations which were incorporated as a handbook with subtitles

1 The Soldier's Foot —How to keep it marching comfortably
2 Minor care of the Feet — How to prevent major troubles

3. Minor care of the Feet.—Pays major dividends.
4. One pair of feet must last a soldier's military lifetime.
5. An army may "travel on its stomach" but it still "marches on its feet."

Army Shoes.—Army shoes are made to look like the *human foot.* The two most important considerations in fitting the soldier's foot are proper length and width. The thickness of the socks makes up for variations or errors in the fitting of the shoes. After the fitting, each soldier is given a small can of lubricating ointment which, when vigorously rubbed into the leather, will make it practically watertight. Officer's shoes had no caps and therefore caused no pressure. However, capless shoes render the wearer more vulnerable to injuries from falling objects and crushing injuries.

I propose an external modification of shoes that I have termed a "4-point landing," or weight-bearing sequence, which produces a proper foot and ankle rhythm. This modification is very valuable for normal feet and for persons who have ankle valgus. I consider a soldier who is wearing an army shoe with the modifications I have suggested, to have more perfect foot balance and rhythm than many soldiers whose feet appear to be in perfect balance. I believe the Army should supply these shoes in complete sizes. This 4-point sequence produces a physiological step. The modification can be standardized very simply by prolonging the inner border of the normal heel from $\frac{3}{4}$ to $1\frac{1}{4}$ inch and elevating it from $\frac{3}{16}$ to $\frac{4}{16}$ inch. The lesser modifications would apply especially in shoes from 7 to 10 in size. Those shoes 10 to 12 in size would require larger modifications.

Shoe Fitting.—Two important criteria in fitting shoes on soldiers are: (1) The space between the end of the great toe and the toe of the shoe should be the width of the thumb; (2) in the unlaced shoe there should be sufficient space under the lower edge of the tongue to admit an index finger.

Improperly fitting army shoes cause blisters, abrasions, callosities, and corns. These may be caused by shoes which are too small, causing pressure, or by shoes which are too large, causing injurious friction. If the tops of the toes are involved, the cap is too low or too stiff. If the ends of the toes are involved, the shoe is too short or too loosely laced. The sides of the big and little toes become irritated when the shoe is too narrow. Improper construction giving a warped or curled insole, or a thick edge of insole, causes irritation along the outer and inner edges of the feet. Irritation at the heel is due to a shoe which is too long, too loosely laced, or which has too wide a heel space for the foot.

The Army had a special center for the *manufacture* of irregular

sized and shaped shoes The local orthopedic surgeons made plaster-of-Paris models which were shipped to the factory where the special shoes were constructed

Some of the various modifications were Extra openings, tongues and laces on the sides and back and abnormal sizes

Some of the deformities requiring special constructed shoes were absence of heel, absence of toes, absence of medial or lateral half of the foot

Special linings are made of lamb's wool for circulatory disturbances

Turning up of the toes of the shoes is prevented by the use of shoe trees Wrinkles of the lining and the leather may cause serious harm

Care of Shoes —*Oiling* —The leather of the sole and welt of the shoe should be kept well oiled in order to prevent the absorption of moisture and to keep the leather supple The upper should not be too heavily oiled in dry weather, because it may interfere with evaporation of perspiration and cause the feet to be constantly hot and sweaty in *warm weather*

Drying —When removed at night, shoes must be carefully dried to prevent them from wrinkling or getting out of shape Rapid drying hardens the leather Shoes can be dried by placing a few warmed pebbles in them and shaking them or stuffing warm cloths in them During winter, shoes must be protected from dampness during the night to prevent moist leather from freezing They can be kept warm by using them as a head rest at night

Army Socks —The soldier's foot should always be clothed in a good sock Thick woolen socks offer a buffer and a support with greater protection against shoe defects If the socks are made with seams or with knots, they should be turned inside-out so that the smooth surface is next to the skin Heavy socks are valuable as padding, as equalizers of shoe fitting, and as protectors

Socks used in marching should be free from holes and from darning, and must be clean Socks should be washed immediately after washing the feet and should be stretched and thoroughly dried before wearing If it is not possible to wash them, they should at least be changed and dirty ones dried and kneaded with the hands to remove dirt and hardness It is also well to change the socks from one foot to the other

Lacing —Broad shoe laces should be used and the shoe properly laced A badly laced shoe will almost certainly cause foot injury following any amount of marching

I have relieved several patients of discomfort by skipping the first pair of eyelets Many soldiers who wear full length uppers double through the middle eyelets to lock the laces one-half way up the shoe

Care of the Feet.—The care of minor ailments of the soldier's foot is of great importance and should be given the utmost attention, because many major conditions necessitating the hospitalization and disability of a great many men may result from neglected or maltreated minor conditions. It should be remembered that, if men are to be kept marching, their feet must be kept in marching condition

Instruction of all officers in the care of soldiers' feet is important. Enlisted men should also be instructed in foot care.

Conditioning Process.—This is accomplished by progressively increasing use. One should bathe the tender feet in warm, salt or alum water.

Preventive Measures Before Marches.—Cut toenails short and square—keep skin clean and dry. Use foot powder freely. Wear clean, dry, whole, unmended well-fitting socks (preferably light wool) with seams and knots outside. Carry an extra pair of socks. Shoes should be fitted while soldier carries a full pack. Some men need special shoes (requires special requisition by senior surgeon to local quartermaster). Break in shoes and alternate pairs, waterproof with neat's foot oil or dubbin. For feet that sweat easily use only saddle soap and polish

During Long March Halts.—Lie with feet elevated part of each halt wash (if possible), dry, massage, powder feet, change socks, drain blisters aseptically and cover with small dressing securely fixed, cover abrasions with band-aid.

After Marches.—Repeat care of feet, wash and dry socks, dry shoes and treat with dubbin or neat'sfoot oil, treat blisters, abrasions, corns and callouses; inspect painful feet for sprains, "march fracture," trichophytosis and improper fitting of socks and shoes.

After prolonged marching under combat conditions men often develop red, swollen, tender skin along the lateral peripheral margins of the plantar surfaces, skin may blister and macerate, require aeration, elevation and rest, and wider shoes as a rule.

Skin Disease.—Skin diseases occuring in combat areas arise largely through unavoidable neglect of hygienic precautions, stress of campaign conditions which divert attention from minor skin injuries and insect bites. Atmospheric heat and humidity in current combat zones plus the infrequency of bathing provide bacteria and fungi with ideal breeding grounds. Minor breaks in the skin favor focis of infection. Fungi require warmth and moisture of encased feet. Contact with motor oil and grass gives rise to dermatitis and enhances the likelihood of pyogenic skin infections.

Liberal and frequent use of foot powder on feet, socks and in shoes tends to keep fungous infections at a minimum.

Uninfected dermatitis of contact and allergic types can be treated by removing the cause and applying calamine lotion.

Cleanliness of the Feet.—Soldiers should be instructed to maintain a reasonable degree of cleanliness of the feet. This will prevent many major foot troubles by preventing the formation of blisters and abrasions in the presence of dirt, dead epithelium, sebaceous secretion and sweat. A daily foot bath in tepid water containing a little mild soap will suffice. In the field, cool water seems to allay the sensation of heat and irritation. After washing, the feet should be carefully dried.

Care of Toenails.—Toenails should be trimmed every ten days or two weeks. They should be cut squarely across. Shaping them at the corners may result in ingrown nails. If toenails are allowed to grow too long, they crack off unevenly and may give rise to paronychia or subungual infections.

Injuries to Toenails.—Injuries from heavy falling objects or similar traumata may cause a subungual hematoma. Pain can be relieved by drilling a hole into the nail to allow for drainage. Care must be taken to prevent secondary infection. If a toenail is partially ripped off, it is best to remove the nail surgically. This will prevent infection and pain resulting from irritation of the partially avulsed nail.

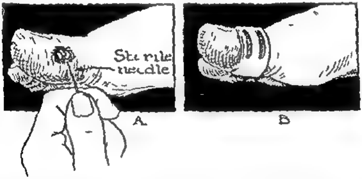


FIG. 355.—Care of blisters and minor burns. The area is cleansed with soap and water and alcohol. The bleb is punctured at its edge with a sterile needle; after the fluid has exuded, a band aid is firmly applied. (Courtesy of Johnson & Johnson.)

Blisters and Abrasions.—The most common causes for blisters and abrasions of the soldier's foot are ill-fitting shoes and socks, poorly constructed shoes, over-riding toes, heat and moisture. These lesions are usually caused by friction, less often by impact and in some instances by pressure. Treatment is directed towards correcting defects in shoes and socks such as projecting nails, folded or worn linings, ill fitting insoles, a tight toe cap and worn or badly darned or soiled socks. Blisters should be touched with a 3.5 per cent solution of tincture of iodine and punctured with a needle whose tip has been sterilized in a flame. Carefully puncture the blister near its lower edge,

allowing the fluid to run out. Do not tear the blister or attempt to remove its covering. The skin should be dried carefully with absorbent cotton or gauze and the blister covered with a piece of zinc oxide plaster, pressing it down smoothly so that the raised epidermis will be pressed back into position.

If plaster is not available, cover the part with sterile petrolatum or zinc oxide ointment, or powder it with issue powder and then protect it with a single turn or, at most, two turns of gauze bandage. After applying the dressings, dust the outside of them and the entire foot with a foot powder. Too much powder will cake and become irritating. The powder lessens the friction on the skin and prevents raw edges of adhesive plaster from adhering to the socks. Careful inspection of the foot should be made for other points of trouble. Areas which are red and tender where no blister has yet occurred should be protected with a piece of adhesive plaster. For those men whose long slender feet and narrow heels make shoe fitting difficult, a properly shaped pad may be placed under the tongue of the shoe in order to prevent irritation of the heel. A strap applied in a figure-of-eight manner may prevent rubbing.

Abrasions are blisters from which the outer layer of skin has been torn off. Small abrasions can be covered with zinc oxide plaster under which they usually heal rapidly. Large abrasions usually suppurate under plaster and should therefore be treated by petrolatum dressings.

Fissures.—Cracks or fissures of the skin between the toes and in the folds of the skin are usually quite painful and tend to bleed readily. They often occur at the margins of callosities where any movement of the foot causes the callus to pull the fissure apart. The treatment consists of washing and drying the feet, dusting with foot powder, and if severe, touching the fissure with a silver nitrate stick. The callus should be pared, and the skin softened.

Corns.—Corns are due to ill-fitting shoes causing continuous injury to the skin. *External corns* can be softened by soaking the foot in warm soap suds and then carefully paring them down several times a month, taking care not to draw blood, because of the possibility of infecting the area. Cutting corns brings only temporary relief. *Soft corns,* which are those located between the toes, require the application of medicine, as a rule, to kill and soften the corn tissues. It is often necessary to remove an exostosis from the underlying phalanx.

The following combinations are effective in assisting in the removal of both soft and hard corns.

Corn Collodion

Salicylic acid	11 parts
Extract of cannabis indica	2 "
Alcohol	10 "
Flexible collodion to make	100 "

A useful corn salve is composed as follows

Salicylic acid	40 parts
Petrolatum	30 "
Lanolin	30

A shoe which once produced a corn should be discarded unless it can be stretched sufficiently so that it no longer causes pressure or irritation of the former corn area

Sweaty Feet —When the feet sweat profusely, the secretion decomposes and becomes foul smelling and offensive The skin between the toes usually becomes macerated, whitish and dead looking, it rubs off easily and is prone to abrasions Treatment consists in washing and thoroughly drying the feet and carefully painting the whole affected area by means of a cotton swab, with the following solution

Commercial formalin (40 per cent solution of formaldehyde)	10 parts
Water	90 "

Allow this to dry If the skin begins to burn, the excess should be washed off This solution should be kept out of abrasions and fissures because of the pain it causes in such lesions A half dozen daily applications will usually suffice to effect a cure, the skin becoming hardened and the secretion altered

Ringworm —Ringworm becomes a serious contagious problem in any congregation of many persons such as occurs in an army camp It is necessary to treat the infection not only individually, but as a group infection Thus, when possible all men should be compelled to bathe their feet in a hypochlorite solution when they walk in their bare feet In the Army, the use of special ointments is the easiest method of attacking the disease once it has become established The patient is instructed to apply the ointment to all the toes nightly for four or five consecutive nights and to dry the feet carefully each morning before putting on his socks

Painful Feet —Painful feet may be due to any of a number of static deformities such as flat-foot or other affections of the longitudinal or transverse arches of the foot Much relief can be afforded by the judicious use of carefully prepared felt pads within the shoes The method used in the application of such pads is described in full on page 107

Painful Heels —Pain around the heel may be due to affections of the tendo Achillis or of the os calcis There may be an inflammation of the tendon itself, of the Achilles bursa, or of the periosteum of the os calcis These affections are usually due to some mechanical cause, most commonly strain or pressure from shoes or leggings Sometimes painful heels are due to gonorrhea and should be treated accordingly

Harmful pressure should be relieved from the irritated point of the

[illegible] size and shape to the [illegible] the tendon of [illegible] is [illegible] improved. A felt pad under the heel [illegible] irritation due to [illegible] of the heel or counter of the shoe should be relieved by removing these points of irritation.

Minor Sprains and Strains.—Minor sprains and strains due to minor trauma can be relieved and the patient [illegible] promptly by the use of the adhesive strapping described on page [illegible], or by the use of elastic adhesive strapping.

Hallux Valgus.—Mild cases will be markedly improved by the use of the army shoe. Severe cases are not likely to be seen since this is a disqualifying condition and will require operative treatment before the soldier is allowed to enlist.

Hammer Toes.—This deformity usually occurs in the second toe. Mild cases may be relieved by strapping a pad on the top of the toe just back of the prominence or applying two narrow strips of adhesive plaster so as to hold the toe straight. Deformities of the little toe may resemble hallux valgus or hammer toe and should be treated on the same principles.

Other Painful Conditions of the Feet.—There are other conditions which may come to the attention of the army surgeon which often can be relieved by contrast dips, massage, felt pads within the shoes and exercises. If these are unsuccessful, the soldier should be treated in a hospital.

March Foot.—March foot, sometimes called "Deutschländer's disease," is a traumatic condition of the second or third metatarsal bone found in some soldiers after strenuous drills or long marching. It usually results in a transverse fracture of the metatarsal shaft in conjunction with a local periosteal reaction. This condition is described in full in Chapter XVII.

ATHLETE'S FOOT

"Athlete's foot" (dermaphytosis) usually occurs between the toes, on the sole and medial aspect of the arch, and at points of contact between skin and footwear. This and other mild chronic cases of fungus infection may respond to daily foot powder application. If they do not, sulfur-resorcin in lotion may be adequate. Relatively resistant "athlete's foot" often clears under half-strength Whitfield's ointment at night. 0.1 to 1.0 per cent tincture of iodine may be effective.

Sulfur-resorcin lotion two to three times daily is satisf[illegible] relatively dry fungous infect[illegible] oot powder may be of val[illegible] ment must be continued [illegible] weeks after the lesion [illegible] in these dermaphytoses.

Acute weeping, *eczematoid stage* of fungous infection should not be treated with fungicides, but by wet dressings or mild drying lotion

Bacterial infection may complicate any disease of the skin, the presence of pus requires attention first to pyogenic infection, then to the underlying condition

Superficial pyogenic lesions of the skin may be treated with 5 per cent sulfadiazine or sulfathiazole ointment Impetiginous lesions also respond satisfactorily to 10 per cent ammoniated mercury ointment

Extensive, spreading or invasive infections should be hospitalized "Desert sore" is an ulcer usually caused by neglected trauma or insect bite Nutritional depletion, fatigue and exposure probably play a part Milder cases are successfully treated with daily sulfanilamide powder and rest, some by cleansing and covering with elastic adhesive plaster The plaster is renewed every five days Some jungle sores respond to neoarsphenamine

TRENCH FOOT

Trench foot became of serious importance to the American Army in France during World War I in 1917 and 1918 It had previously assumed great importance to the British soldiers in France However the lesion as we know it, had been described by Larry who was Napoleon's chief surgeon He encountered it in the Crimean War

Trench foot appeared during World War I in soldiers in the trenches of France, as a result of exposure to cold and dampness and constriction by footwear, puttees, and leggings It caused intense pain, discoloration, and finally gangrene

The trench foot problems that arose during World War II were quite different from those of World War I In World War I the situation was one of mass involvement in immense or extensive trenches with thousands of men in one trench

In World War II there were often thousands of men in thousands of one man "trenches," i e, foxholes In the large trenches, men could walk about and even lie down, whereas, in a foxhole is was impossible to do either There were puddles of water

The pathological changes are in the nature of an angioneurosis in the pregangrenous stage Sweet, Norris, and Wilmer stated that trench foot starts from the interior and that the infections which often mark the course of the disease are the secondary manifestations of the reaction of devitalized tissue to infective agents The symptoms are burning pain and hyperesthesia The skin is red and beefy

By the time a trench foot patient was transferred to the orthopedic section at one of the vascular centers of a general hospital, he had had the benefit of all recognized general measures, oftentimes surgery

He was transferred in order to give him the benefit of physical measures which consisted chiefly of:

1. Balancing his feet, ankles, and legs by modification of shoes.
2. Supporting his longitudinal and metatarsal arches.
3. Measures to transfer his weight from painful areas.
4. Door stop exercises.
5. Rolling pin exerciser.
6. Rocker chair attachment to chair. Every available modality was employed in physical therapy, occupational therapy and reconditioning.

The patient was admonished to beware of the bad habit of resting on his toes especially while sitting.

Prognosis.—Recovery and equalization of blood-pressure of the arms and legs are coincident. Either the pressure in the leg decreases or that in the arm increases. Difference in blood-pressure between arm and leg may range from 8 to 30 mm. There is equalization of blood-pressure and relief from pain coincident with the administration of potassium iodide. It is possible to return the mild cases to duty in three weeks; the severe cases require three months. Recurrence is common.

Late complications are: atrophy of intrinsic muscles of the feet; gangrene; automatic amputations; infection; psychoneurosis.

Treatment.—The treatment consists of prophylactic and curative measures. Prophylactic measures are as follows: Change men often; keep the trenches as dry as possible. Before entering trenches: loose fitting rubber hip boots; shoes and puttees must be loose; socks without holes; no garters; oil feet with whale oil or antifrostbite grease, rub in with caution; it has an offensive odor and may hurt infections or abrasions. Dry socks and dry boots are important.

During the activities of the Marines, the shoes and feet often become soaked and wet. This may produce a neurocirculatory disturbance which can be guarded against by means of prophylactic measures such as the early recognition and change to dry shoes.

Care in trenches: Remove shoes daily, rub feet well, grease feet, dry socks; lie down on tarpaulin and do overhead exercises. Maintain body warmth. Dry boots or shoes on a rack; stamp feet and move toes inside boots frequently. Warm food should be eaten twice daily. Trench foot wash-houses should be provided. Soak feet and wash, using warm water and soft soap. Dry feet and dust with:

Powdered camphor	25
Talc	1000

Treatment of Attack—Mild.—Warm foot bath daily; tap bullæ; high-frequency current; for abrasions give antitetanic serum.

Severe—Keep patient in casualty clearing station five to six days, elevate legs, expose to air and sun if possible, expose to electric light bath, massage twice daily when edema is gone, use oil

The treatment includes the administration of thyroid, potassium iodide, and vitamin B_1, protection against exposure and infection, ultra-violet irradiation, contrast baths, massage, hot paraffin dips, and postural exercises Sympathetic nerve injections and operations may be necessary I suggest K I as a prophylactic agent against recurrence

Treatment
1 One soldier should place his foot against the body of his buddy for warmth
2 Maintain movements of feet and legs
3 Use gentle massage—do not rub with a bath towel
4 Give tetanus toxoid if skin is broken
5 Apply mild dressing from ten to fourteen days
6 Do not walk any more than necessary
7 Bring transportation vehicle to the victim
8 Give warm drinks
9 Sympathetic nerve blocks

In the prevention of trench foot it is important that every soldier be instructed in the care of his feet while he is in a foxhole He is also instructed in the care of his feet while he is in the line before, during, and after a campaign If a soldier is to go into another campaign he must come out of the previous campaign with two good feet

CHILBLAIN AND FROSTBITE

Effects of Extreme or Prolonged Cold—The vasoconstriction of superficial blood-vessels that accompanies exposure of skin to cold may deprive tissue of adequate blood supply if such a physiological state is prolonged This probably occurs among shipwrecked sailors and among soldiers that must remain stationary in wet and cold trenches or fox holes Constricting clothing like shoes, pressure on blood-vessels and dependency in position of a limb add to circulatory embarrassment Numbness, swelling, and waxy appearance of the feet are early signs, redness, blistering and pain follow In the conditions known as "immersion foot, "trench foot" and "chilblains," the nutritional status of the victim is an important factor in the affection course of the disease

Treatment is based on maintaining the skin unbroken and slowing up the repair processes in order to minimize edema Elevation, cleanliness, and dry refrigeration of the involved part with ice or cold air for several days is advisable Local metabolism and inflammatory repair

must be taken care of. Diets fortified with extra vitamins and systemic sulfonamides for infection are valuable adjuncts.

Freezing from temperatures below 14° F. causes acute death of tissue due to physical change (crystallization of fluids) in the tissue structure plus vasoconstriction. Avoid rubbing where skin is involved, thawing is best carried out slowly by using body heat. Place frozen part in armpit or between thighs and allow to thaw. Pain suggests that thawing is too rapid. Cool down again with cold water or air. Peripheral nerve or ganglion block may help pain and circulation in the limb. Then treat as a soft tissue injury. One must avoid infecting the damaged part.

Chilblain is frostbite. First degree frostbite is merely reddening, smarting or aching of the skin, *i. e.*, mild inflammation. In second degree frostbite blisters form.

The emergency treatment of chilblain, like that of frostbite, is too often overdone. Only the gentlest rubbing or friction, if any, should be applied.

From his five years in the Arctic, Stefansson, famous Arctic explorer, learned that the best emergency treatment for frostbite was to hold a warm dry hand on the spot for a little while, very gently kneading it. but not rubbing it. If necessary, warm the hand first by holding it in the armpit.

Manipulation of the frostbitten part should cease the instant the blanching disappears and the natural pink color returns.

Do not apply ice, snow or cold water to a frosted or frozen member, and do not unnecessarily keep the patient in a cold or cool place if there is a warm place available.

To relieve the itching, smarting and aching of chilblain, bathe the surface with a teaspoonful of alum in a pint of warm water, then dry by pressing with a soft towel and powder with talcum or borated talcum powder.

Blisters may be punctured with a sterile needle, knife or scissors after the skin has been sterilized. Borated talcum powder is dusted on and a sterile dressing is applied. The insides of stockings and shoes are dusted with talcum.

It is not advisable to apply ointments to frostbitten skin.

Hot coffee, tea or broth are the best stimulants for persons rescued from severe exposure to cold. Never give alcoholics. Apply warm blankets and artificial heat to the extremities and to the body, but do not overheat the room.

In 1915, during World War I there was a blizzard in Gallipoli which caused nearly 16 thousand cases of frostbite in one week. In Flanders they had 3,400 cases in one week.

During World War II frostbite was a geographical problem of serious

importance to the American soldier. It first became serious during the Attu Islands campaign.

In Italy at one time the American troops had 100 cases of trench foot and frostbite per week. In the Cassino theater of war in Italy it was a serious problem and also in the Battle of the Bulge in and around Bastogne during the latter part of 1944 and early in 1945.

FIG. 350.—The bones in a case of trench foot. Note atrophy, destruction and partial amputation. (Mayo General Hospital case.)

Prophylaxis and Curative Measures.—It was important in high altitude bombers of the Air Corps. The first phase is:

A. Local—with vasoconstriction that is persistent.

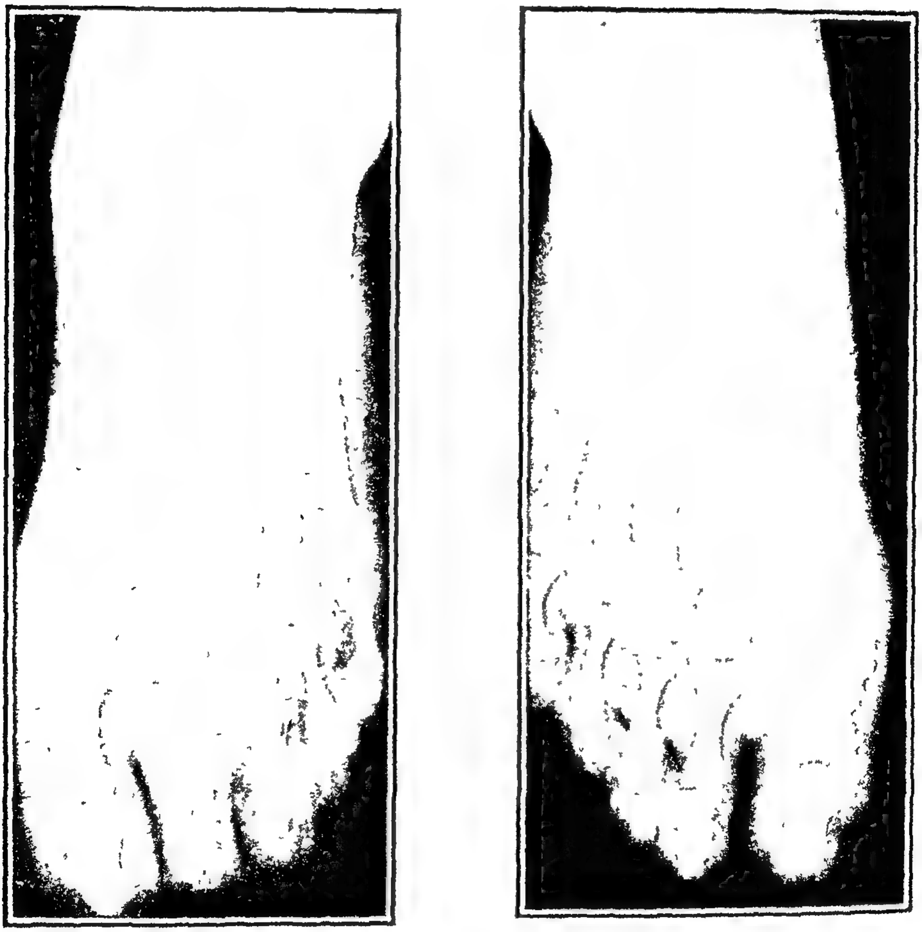
B. Then there is reflex generalized vasoconstriction.

A temperature of 50° produces numbness, tingling, and loss of perception.

A temperature of 28° produces freezing. Dampness and freezing produce damage to tissue.

True Frostbite.—The onset of true frostbite may be sudden or gradual.

Sudden frostbite develops in exceptionally cold weather, especially in a high wind, or when the exposed skin is brought into contact with cold metal such as an ice-axe, a rifle, a spoon, or the shutter-release of a camera. A sting like that of a wasp is usually felt, but sometimes it is painless. The skin is white and crystalline.



A B

FIG. 357.—Bone lesions in a case of trench foot. (Mayo General Hospital.)

Greene found that if frostbite is observed at once and a warm hand clapped on it, no harm may be done. During thawing, a red area appears around the frozen patch which gradually invades it. The surroundings gradually return to normal, leaving the patch red and sharply defined. Shortly afterwards itching and swelling begin. The wheal may take many hours to subside, or blistering may follow, and even deep gangrene of the skin. The flush is due to the opening up of

arterioles by the release of H-substance from the damaged area (Lewis and Love)

Gradual frostbite may occur on exposed skin or on well-clothed parts. The burning sensation of extreme cold dies away and a pleasant numbness takes its place. At this stage the skin may appear normal or may be white and waxy. If freezing continues, there is destruction of tissue, blood-vessels give way, edema and hemorrhage appear and the vitality of the tissues is destroyed—a course of events which may occasionally be delayed by cold so extreme that the normal contour of the part is preserved.

In either form thawing usually begins before extreme damage has been done, and is itself responsible for the ultimate damage. This is the danger period. As in sudden freezing, a flush surrounds the frozen area and gradually invades it, until the normal or white skin becomes red. Swelling begins when transudation takes place from the damaged vessels. In extreme cases whole blood may escape into the tissues and the skin becomes darkened or purple, blisters then form, the blebs containing straw-colored fluid or whole blood. The true severity depends on the depth of freezing and—more important—the amount of transudation.

In most cases the damage is only skin deep or involves only the terminal phalanges. The appearance is always unduly alarming to the inexperienced. A frostbitten foot may have precisely the appearance of a foot in which the main arteries have been blocked by embolism, but arterial pulsation can usually be felt and recovery with but little tissue loss is the rule if sepsis is avoided.

Frostbite gangrene of the lower extremities is one of the most important medical problems in the military services. Even if frostbite was noticed very early in its course, by the time many victims were transported to base hospitals ascending gangrene had already begun. A tremendous number of amputations have been performed for gangrene due to frostbite.

Military surgeons have been trying to find means of preventing frostbite, and improving the transportation of victims to base hospitals. As an alternative, an attempt has been made to treat such patients properly at the front so that gangrene will not spread or cost a life before surgical aid can be properly administered.

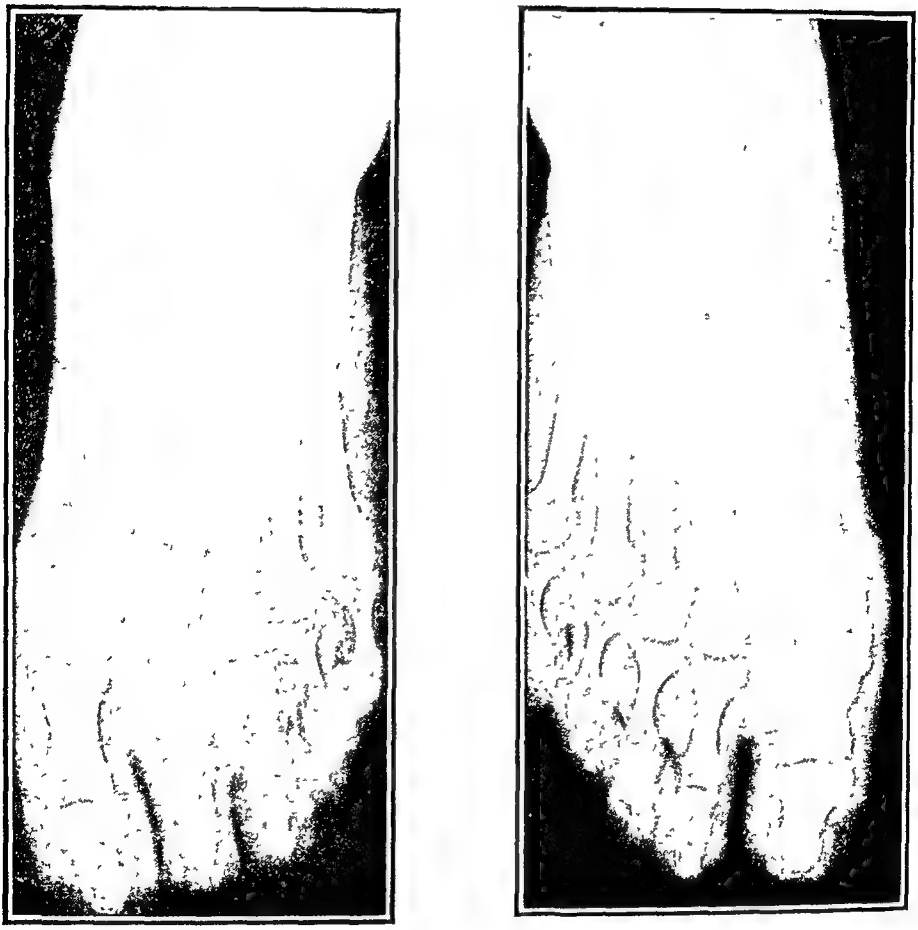
Airplane ambulances obviously reduced the death rate and saved many a frozen limb from amputation.

The method used was as follows. As soon as frostbite was noticed, the nerves above the frozen area were blocked with novocaine by the surgeon at the battlefront. The leg was immediately dressed with massive warm dressings and the victim sent to a base hospital as quickly as possible.

A temperature of 28° produces freezing. Dampness and freezing produce damage to tissue.

True Frostbite.—The onset of true frostbite may be sudden or gradual.

Sudden frostbite develops in exceptionally cold weather, especially in a high wind, or when the exposed skin is brought into contact with cold metal such as an ice-axe, a rifle, a spoon, or the shutter-release of a camera. A sting like that of a wasp is usually felt, but sometimes it is painless. The skin is white and crystalline.



A B

FIG 357.—Bone lesions in a case of trench foot (Mayo General Hospital.)

Greene found that if frostbite is observed at once and a warm hand clapped on it, no harm may be done. During thawing, a red area appears around the frozen patch which gradually invades it. The surroundings gradually return to normal, leaving the patch red and sharply defined. Shortly afterwards itching and swelling begin. The wheal may take many hours to subside, or blistering may follow, and even deep gangrene of the skin. The flush is due to the opening up of

arterioles by the release of H-substance from the damaged area (Lewis and Love)

Gradual frostbite may occur on exposed skin or on well-clothed parts The burning sensation of extreme cold dies away and a pleasant numbness takes its place At this stage the skin may appear normal or may be white and waxy If freezing continues, there is destruction of tissue, blood-vessels give way, edema and hemorrhage appear and the vitality of the tissues is destroyed—a course of events which may occasionally be delayed by cold so extreme that the normal contour of the part is preserved

In either form thawing usually begins before extreme damage has been done, and is itself responsible for the ultimate damage This is the danger period As in sudden freezing, a flush surrounds the frozen area and gradually invades it, until the normal or white skin becomes red Swelling begins when transudation takes place from the damaged vessels In extreme cases whole blood may escape into the tissues and the skin becomes darkened or purple, blisters then form, the blebs containing straw-colored fluid or whole blood The true severity depends on the depth of freezing and—more important—the amount of transudation

In most cases the damage is only skin deep or involves only the terminal phalanges The appearance is always unduly alarming to the inexperienced A frostbitten foot may have precisely the appearance of a foot in which the main arteries have been blocked by embolism, but arterial pulsation can usually be felt and recovery with but little tissue loss is the rule if sepsis is avoided

Frostbite gangrene of the lower extremities is one of the most important medical problems in the military services Even if frostbite was noticed very early in its course, by the time many victims were transported to base hospitals ascending gangrene had already begun A tremendous number of amputations have been performed for gangrene due to frostbite

Military surgeons have been trying to find means of preventing frostbite, and improving the transportation of victims to base hospitals As an alternative, an attempt has been made to treat such patients properly at the front so that gangrene will not spread or cost a life before surgical aid can be properly administered

Airplane ambulances obviously reduced the death rate and saved many a frozen limb from amputation

The method used was as follows As soon as frostbite was noticed, the nerves above the frozen area were blocked with novocaine by the surgeon at the battlefront The leg was immediately dressed with massive warm dressings and the victim sent to a base hospital as quickly as possible

The cost of otherwise healthy young males for war service has been appalling because of limbs lost through frostbite.

During the stage of aseptic recovery, the non-viable tissues become black, hard and painless, and finally—sometimes after weeks—strip off, leaving healed skin beneath. The viable but affected tissues gradually recover their normal appearance, but may be hypesthetic, or paresthetic and hyperesthetic for months. Even in a mild case with little or no tissue loss, these disturbances of sensation may occur, and interference with the blood supply to the nail-bed may result in temporary cessation of nail growth and loss of the old nail some months later. Many years may pass before nail growth becomes normal again

SHELTER LEGS

In a December, 1940, issue of the *Lancet,* there appeared an article on "Shelter Legs." This is a neurocirculatory condition where the local water balance is disturbed. It occurred in people who slept in bomb shelters where the air was cold and damp. Many of these people slept on deck chairs with one or more rungs supporting their feet and legs. During sleep, when circulation is at low ebb, combined with dampness and cold, there appeared swelling of the legs, pain, and disability. The chief factors were restriction in activity, fatigue, cold, dampness; calcium deficiency, vitamin deficiency, static defects and varicose veins. *Treatment is based upon the etiological factors.*

Prolonged sitting or reclining in a steamer deck chair can cause circulatory disturbance.

High Altitude Frostbite.—(Davis, Scarff, Rogers and Dickinson*.) Cold damage to the extremities suffered by the high altitude airman is unique among injuries of thermal origin. One fundamental fact is common to the frostbite incurred by ground troops during severe winter weather, and the immersion foot of shipwrecked seamen; namely, that the primary agent which produces the pathologic changes in the affected tissues is *cold.*

The secondary mechanisms, however, which operate to make the tissues particularly vulnerable to cold, differ.

In high altitude frostbite, extreme degrees of cold (−40 to −52° C.) are encountered. The effect of these low temperatures upon the tissues of the extremities is further augmented by varying degrees of anoxemia and ischemia. In the frostbite incurred by ground troops the flat surfaces of the face and of other exposed portions of the body, as well as the extremities may be attacked; whereas, in high altitude frostbite one of the most striking features is the predilection for the

* Davis, Scarff, Rogers and Dickinson. High Altitude Frostbite Surg. Gynec. and Obst., 77, 561, 1943

extremities In immersion foot the degree of cold is moderate in comparison and the secondary factors are venous stasis, maceration of the skin by sea water, infection of the soft parts introduced through the macerated skin, malnutrition, and lowered general vitality due to sheer physical exhaustion In the frostbite of the high altitude flyer the exposure to cold may last only a few minutes, whereas in the frostbite of ground troops or the immersion foot of the seaman, the exposure to cold may be for days or even weeks

Anesthesia or hypesthesia to pain and touch is always present to some degree in the affected extremities and commonly extends well proximal and beyond the areas of apparent damage to the skin itself These changes may persist for months

Pathology —From a pathological viewpoint, the most striking feature of high altitude frostbite is the fact that whereas the face may be exposed to severe cold for several hours without apparent damage, exposure of the fingers to the same degree of cold for only a few minutes may produce damage to tissue so great that gangrene and loss of fingers will result It must be assumed that the inherent tolerance for cold in a warm blooded animal having a relatively constant body temperature is essentially the same for all tissue cells

Generalized anoxemia, when it occurs, undoubtedly plays a major rôle in the production or augmentation of tissue damage due to cold in high altitude frostbite but its effects cannot possibly be selective for tissues in one part of the body

Acute peripheral vasoconstriction of the vessels in the extremities occurs almost simultaneously with the exposure to cold It takes place principally at the terminal end of the arterioles Direct microscopic examination of the terminal capillary beds in the finger tips soon after they have been exposed to intense cold has revealed the peripheral ends of the arterioles well filled with blood but the terminal capillary loops are entirely empty The evidence thus far obtained indicates that this vasoconstriction may persist for twenty-four hours or longer

The basic morphological lesion in high altitude frostbite consists of damage by cold to the endothelium of the terminal capillary loops In mild cases this results only in a pathologic permeability of the capillary walls, but in the more serious cases a thrombus formation occurs at the arteriolar-capillary junction Under the microscope these thrombi in the terminal stumps of the arterioles are plainly visible No thrombosed capillaries have been seen, presumably because early in the train of events they have been deprived of their blood by the intense vasoconstriction which takes place at the terminal ends of the arterioles

If the vasoconstriction of the arterioles is relaxed before the throm-

bosis takes place, and the capillary bed is flooded with blood, extravasation of plasma or whole blood may occur through the damaged capillary walls into the tissues. This extravasated fluid may be held within the skin which then assumes an edematous appearance, or it may collect as free fluid in vesicles. Eventually, the transudate accumulates in the tissue plane between the epidermis and the dermis immediately beneath, or deeper to, the basal germinal layer of cells of the epidermis. The germinal layer and the terminal capillary loops are dissected away from the underlying tissues. Small, irregular capillary loops begin to grow out of the stumps of the thrombosed arterioles after three to four months. The clinical picture simply progresses directly from injury by cold to dry gangrene.

The arteries show interesting changes. In 3 cases, requiring amputation of the little finger three months after injury from cold, the smaller arteries and arterioles showed a remarkable thickening of the intima which was eight to ten times the normal. The vessels resembled those seen in cases of endarteritis obliterans. The endothelial lining of the vessels was everywhere intact; no thrombi were seen and nowhere was there a suggestion of recanalization of an earlier thrombus. The mechanisms producing these changes are not clear. However, such changes are said to follow long repeated vasomotor overactivity. The veins were not involved in these pathological changes.

Neural injuries are suggested clinically by the sensory changes in the skin and by the topographical and chronological relationships existing between sensory loss and loss of sweating. Histological studies of nerves have not been successfully made because of the difficulty in obtaining suitable tissue. Whether the loss of sweating is due to local damage to sympathetic nerve fibers or to direct injury to the sweat glands themselves has not as yet been definitely established.

Treatment.—The treatment of high altitude frosbite must be directed in the first instance to the prevention of these injuries by reducing the necessary exposure to cold and the risks of general anoxemia. These factors are always subject to dislocation in the heat of battle and their reduction falls within the province of the tactician and the engineer.

Localized anoxemia of the extremities due to reflex vasospasm is, however, a straightforward medical problem. Its prevention and treatment present a challenge to the physician.

Three types of protective ointments have been studied upon the extremities of normal individuals and patients in whom cold damage has occurred from the viewpoint of preventing the lowering of skin temperature. Careful studies of skin temperature readings after controlled exposures to cold have not yielded results which would indicate that such a line of investigation would prove profitable.

Release of vasoconstriction and its attendant ischemia appear to

be a matter of prime importance in the treatment of these cases and must be obtained early if the measure is to be effective, that is, before thrombosis has taken place. Vasodilatation may be brought about in the extremities in several ways.

The simplest way to produce vasodilatation is by the local application of heat, but the degree of warmth which should be applied to a frostbitten extremity during the early hours or days of treatment is a moot question. Greene has recommended that the frostbitten extremity be kept at a temperature approximately plus 2 to plus 5 degrees centigrade, because in his opinion heat to the frozen part increases its metabolism and its oxygen requirements and encourages the growth of bacteria and because warmth increases the flow of blood to the part, resulting in greater transudation and blistering. Greene cites Lake's work which showed that the survival rate of tissue cultures is greatest between minus 5 degrees centigrade and plus 5 degrees centigrade.

In line with this reasoning Greene has devised a therapeutic refrigerator. It contains one compartment in which solid carbon dioxide is placed and a second compartment into which the frostbitten extremities may be placed. The former communicates with the latter through vents which can be opened and closed as desired to regulate the temperature which is recorded by a thermometer and can be read from outside the box. It is possible to reduce the temperature in the compartment in which the extremities are placed as low as minus 20 degrees centigrade. He advises treatment of frostbitten extremities by placing them in the cabinet with the temperature of the air in the compartment set at plus 2 or 3 degrees centigrade and keeping them there for several days, or even a week, until their removal from the cold cabinet to room temperature is no longer followed by pain in the affected parts.

Greene's refrigerator is certainly an ingenious apparatus and very useful for establishing controlled conditions for studying the effect of cold upon normal and frostbitten extremities. Davis is not yet prepared, however, to accept without reservation his ideas regarding t' therapeutic value of cold in the treatment of the cold damage incurred by high altitude flyers.

It does not necessarily hold that, because temperatures betwee minus 5 and plus 5 degrees centigrade are optimum for tissue cultures *in vitro*, bathed with nutrient fluid, the same temperatures a optimum for the metabolism of adult tissue cells *in vivo* and depe for their vitality upon the exchange of gases in the circulating bloc Sir Thomas Lewis states categorically, "If the skin is sufficiently c 10 degrees centigrade (50 degrees F) or less, the blood will not p with its oxygen." If one assumes Lewis to be correct, it is d to reduce the temperature of the already damaged tissues below

bosis takes place, and the capillary bed is flooded with blood, extravasation of plasma or whole blood may occur through the damaged capillary walls into the tissues. This extravasated fluid may be held within the skin which then assumes an edematous appearance, or it may collect as free fluid in vesicles. Eventually, the transudate accumulates in the tissue plane between the epidermis and the dermis immediately beneath, or deeper to, the basal germinal layer of cells of the epidermis. The germinal layer and the terminal capillary loops are dissected away from the underlying tissues. Small, irregular capillary loops begin to grow out of the stumps of the thrombosed arterioles after three to four months. The clinical picture simply progresses directly from injury by cold to dry gangrene.

The arteries show interesting changes. In 3 cases, requiring amputation of the little finger three months after injury from cold, the smaller arteries and arterioles showed a remarkable thickening of the intima which was eight to ten times the normal. The vessels resembled those seen in cases of endarteritis obliterans. The endothelial lining of the vessels was everywhere intact, no thrombi were seen and nowhere was there a suggestion of recanalization of an earlier thrombus. The mechanisms producing these changes are not clear. However, such changes are said to follow long repeated vasomotor overactivity. The veins were not involved in these pathological changes.

Neural injuries are suggested clinically by the sensory changes in the skin and by the topographical and chronological relationships existing between sensory loss and loss of sweating. Histological studies of nerves have not been successfully made because of the difficulty in obtaining suitable tissue. Whether the loss of sweating is due to local damage to sympathetic nerve fibers or to direct injury to the sweat glands themselves has not as yet been definitely established.

Treatment.—The treatment of high altitude frosbite must be directed in the first instance to the prevention of these injuries by reducing the necessary exposure to cold and the risks of general anoxemia. These factors are always subject to dislocation in the heat of battle and their reduction falls within the province of the tactician and the engineer.

Localized anoxemia of the extremities due to reflex vasospasm is, however, a straightforward medical problem. Its prevention and treatment present a challenge to the physician.

Three types of protective ointments have been studied upon the extremities of normal individuals and patients in whom cold damage has occurred from the viewpoint of preventing the lowering of skin temperature. Careful studies of skin temperature readings after controlled exposures to cold have not yielded results which would indicate that such a line of investigation would prove profitable.

Release of vasoconstriction and its attendant ischemia appear to

be a matter of prime importance in the treatment of these cases and must be obtained early if the measure is to be effective, that is, before thrombosis has taken place. Vasodilatation may be brought about in the extremities in several ways.

The simplest way to produce vasodilatation is by the local application of heat, but the degree of warmth which should be applied to a frostbitten extremity during the early hours or days of treatment is a moot question. Greene has recommended that the frostbitten extremity be kept at a temperature approximately plus 2 to plus 5 degrees centigrade, because in his opinion heat to the frozen part increases its metabolism and its oxygen requirements and encourages the growth of bacteria and because warmth increases the flow of blood to the part, resulting in greater transudation and blistering. Greene cites Lake's work which showed that the survival rate of tissue cultures is greatest between minus 5 degrees centigrade and plus 5 degrees centigrade.

In line with this reasoning Greene has devised a therapeutic refrigerator. It contains one compartment in which solid carbon dioxide is placed and a second compartment into which the frostbitten extremities may be placed. The former communicates with the latter through vents which can be opened and closed as desired to regulate the temperature which is recorded by a thermometer and can be read from outside the box. It is possible to reduce the temperature in the compartment in which the extremities are placed as low as minus 20 degrees centigrade. He advises treatment of frostbitten extremities by placing them in the cabinet with the temperature of the air in the compartment set at plus 2 or 3 degrees centigrade and keeping them there for several days, or even a week, until their removal from the cold cabinet to room temperature is no longer followed by pain in the affected parts.

Greene's refrigerator is certainly an ingenious apparatus and very useful for establishing controlled conditions for studying the effect of cold upon normal and frostbitten extremities. Davis is not yet prepared, however, to accept without reservation his ideas regarding the therapeutic value of cold in the treatment of the cold damage incurred by high altitude flyers.

It does not necessarily hold that, because temperatures between minus 5 and plus 5 degrees centigrade are optimum for tissue cultures *in vitro*, bathed with nutrient fluid, the same temperatures are optimum for the metabolism of adult tissue cells *in vivo* and dependent for their vitality upon the exchange of gases in the circulating blood. Sir Thomas Lewis states categorically, "If the skin is sufficiently cold, 10 degrees centigrade (50 degrees F.) or less, the blood will not part with its oxygen." If one assumes Lewis to be correct, it is illogical to reduce the temperature of the already damaged tissues below 10

degrees centigrade to the levels of 2 to 5 degrees centigrade recommended by Greene. The point stressed by him that the metabolic requirements of the tissues are lowered at the temperature he recommends seems of little consequence in comparison with the fundamental fact that no oxygen is released by the blood to the tissues at these temperatures.

With this in mind, experiments were carried out with amyl nitrate, nitroglycerin, alcohol and aspirin. These drugs were administered both to normal persons and to patients who had recently received injuries to their fingers from excessive cold. The effect of these drugs on the peripheral capillary circulation was studied by means of electric thermocouples and simultaneous direct microscopy of the capillaries themselves. Contrary to the generally accepted action as reported in textbooks, none of these drugs caused an elevation of the temperature in the tested parts, nor did they cause a dilatation of the capillary bed.

Similar experiments with drugs acting upon blood-vessel walls through the medium of the autonomic nervous system have also been carried out with similar negative results.

Blocking of the sympathetic nerve trunk and the stellate ganglion with novocain has been performed in patients suffering at the time from acute vasoconstriction as a result of exposure to intense cold. The results obtained tended to establish the fact that acute dilatation of the peripheral capillary bed could be effected in extremities in which there had not been permanent anatomical injury to the capillary wall, or thrombosis at the arteriolar-capillary junctions. On the other hand, as would be expected in the more seriously affected extremities in which these two pathological changes had already occurred, blocking of the sympathetic trunk and the stellate ganglion failed to produce either a rise in the skin temperatures of the finger tips or a reappearance of blood in the terminal capillary beds.

IMMERSION FOOT

When first seen after exposure either ashore or afloat the feet are cadaveric in color, swollen, and blistered. Massive gangrene from the ankle down may appear imminent but in the absence of infection and with proper treatment the capacity for recovery is amazing. It takes place in two stages, an early hyperemic stage, and a later period of fibrosis. If the exposure has been severe and prolonged, pain may be severe in both and a cause of prolonged incapacity.

Treatment.—When men with chilled, numb, swollen, and blistered lower legs are first seen by a medical officer Captain White advised that they must be kept off their feet and the skin protected against rupture

of the blebs and the formation of pressure sores in the weight-bearing areas of anesthetic skin. Once streptococcal infection starts, moist gangrene and loss of leg are likely to follow. First aid should therefore begin by having the patients carried to the Sick Bay or hospital near the front lines and kept in bed. Entirely different forms of treatment are required for the general effects of cold and the local damage from exposure.

The body should be warmed externally by covering with blankets and by hot water bottles, internally by drinking hot soup, coffee, or tea. The men should be given nutritious easily digested food with a high protein vitamin content as soon as it can be tolerated. In the sickest survivors vitality may have been so reduced by cold and starvation that emergency treatment for shock is needed. Transfusion of plasma will then play a double rôle by restoring depleted fluid volume and by combating hypoproteinemia.

It is vitally important to keep the injured feet cool, while the body of the chilled patient is warmed. This is best accomplished by exposing the legs below the knees to a cool room temperature and directing a blast of air from an electric fan or blower over them. Never rub these feet or paint the blistered areas with strong disinfectants. These areas should be handled like a second degree burn with aseptic precautions (including masking of the dresser's nose and mouth), sulfonamide therapy, and a "booster" dose of tetanus toxoid. Elevating and cooling the legs will help drain the edema fluid and cause the blisters to shrink. During the period of sterile inflammation the hyperemia of the deeper tissues, which are always less damaged than the skin by cold, will cause the surface temperature to rise above 90 *degrees*. Unless this excessive heat is reduced, ecchymosis will increase, blisters swell, and pain becomes acute. The explanation of this is that warming increases the metabolic demand for oxygen on the part of the cutaneous cells to a greater extent than can be met by the impaired supply of blood through the injured subcutaneous vessels. Anoxia therefore ensues with throbbing pain, increased extravasation of fluid, and necrosis of the skin.

SKI TROOPS LESIONS OF THE FOOT AND ANKLE

The most common lesions of the foot and ankle that occur among ski troops are fractures, sprains and dislocations.

CHAPTER XXXIV

THE RELATION OF BACK, PELVIS, HIP, THIGH, KNEE AND CALF TO THE FOOT AND ANKLE

It is impractical from the standpoint of function to isolate the foot and ankle from other weight-bearing structures which are in the leg, knee, thigh, hip, pelvis and lower back. There is a close relationship between foot disturbances and those of other parts of the body, especially in the hip, sacro-iliac and lumbo-sacral areas. The general health of the patient can be definitely disturbed physically and mentally by foot disturbances and painful feet. I have therefore included a short chapter bridging the gap. The anatomy of the thigh, knee and leg is shown in several accompanying illustrations. Infections of the foot and ankle may produce their first manifestations in the inguinal lymph nodes before the primary lesion is discovered.

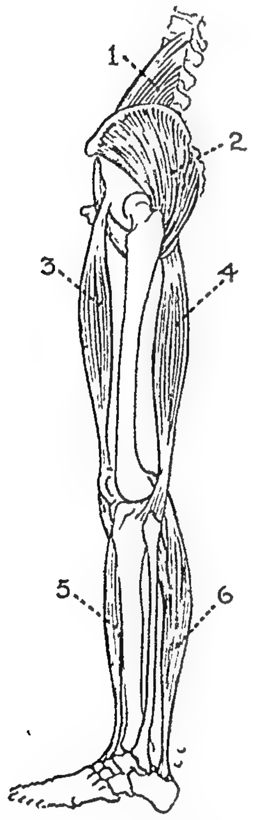


Fig. 358.—Diagram representing: 1, Iliopsoas; 2, gluteus maximus; 3, quadriceps; 4, hamstrings; 5, flexors of the ankle; 6, extensors of the ankle. (Redrawn from Mackenzie, The Action of Muscles, courtesy of Paul B. Hoeber, Inc.)

Some of the conditions occurring in the leg and thigh which have a reciprocal effect on the foot and ankle include fractures, dislocations, sprains, infections, arthritis and deformities such as bow-legs and knock-knees.

Back—Pelvis—Thigh.—A person with sway-back feels better in shoes with higher heels. A patient with flat back is able to wear low heels with comfort. The sacro-iliac joints may be seriously affected by foot disturbances, especially the mechanical ones, or painful ones which change the patient's tread, throwing the pelvis, hip and sacro-iliac joints out of balance and therefore creating strain. Pelvic imbalance may often be corrected by raising the heel of one's shoe in such conditions as low back pain, "sciatic neuritis," lumbosacral arthritis, sacro-iliac arthritis, and arthritis of the hip and knee.

In such conditions an imbalance of the foot, ankle, and leg are very important, and may preclude a good result in spite of every other prepared remedy and measure The calf of the leg is very important and is intimately bound up with the foot and ankle in many conditions Rupture of the plantaris tendon will affect the foot and ankle to a serious degree producing disability, pain and limp It is not too far removed to discuss the psoas and abdominal muscles, the gluteal

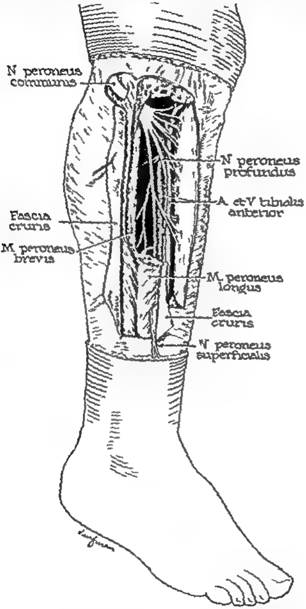


FIG 359 —Dissection of leg to show relations of external peroneal nerve

and piriformis muscles, and the tensor fasciæ latæ The fascial spaces of the thigh so accurately described by Prentiss, Milgram, and Steindler deserve the attention of everyone interested in the foot and ankle

In the treatment of leg, knee, thigh, hip and back disturbances, a foot and ankle may be put out of line, or so weakened after the origi-

CHAPTER XXXIV

THE RELATION OF BACK, PELVIS, HIP, THIGH, KNEE AND CALF TO THE FOOT AND ANKLE

It is impractical from the standpoint of function to isolate the foot and ankle from other weight-bearing structures which are in the leg, knee, thigh, hip, pelvis and lower back. There is a close relationship between foot disturbances and those of other parts of the body, especially in the hip, sacro-iliac and lumbo-sacral areas. The general health of the patient can be definitely disturbed physically and mentally by foot disturbances and painful feet. I have therefore included a short chapter bridging the gap. The anatomy of the thigh, knee and leg is shown in several accompanying illustrations. Infections of the foot and ankle may produce their first manifestations in the inguinal lymph nodes before the primary lesion is discovered.

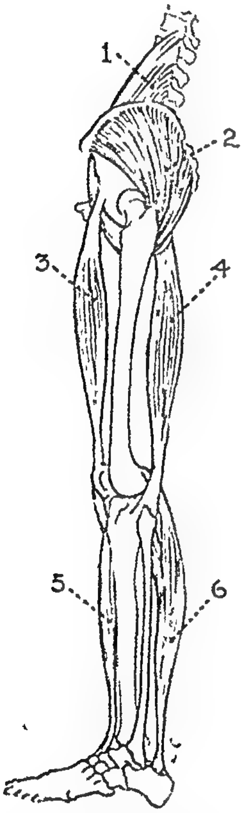


Fig. 358.—Diagram representing: 1, Iliopsoas; 2, gluteus maximus; 3, quadriceps; 4, hamstrings; 5, flexors of the ankle; 6, extensors of the ankle. (Redrawn from Mackenzie, The Action of Muscles, courtesy of Paul B. Hoeber, Inc.)

Some of the conditions occurring in the leg and thigh which have a reciprocal effect on the foot and ankle include fractures, dislocations, sprains, infections, arthritis and deformities such as bow-legs and knock-knees.

Back—Pelvis—Thigh.—A person with sway-back feels better in shoes with higher heels. A patient with flat back is able to wear low heels with comfort. The sacro-iliac joints may be seriously affected by foot disturbances, especially the mechanical ones, or painful ones which change the patient's tread, throwing the pelvis, hip and sacro-iliac joints out of balance and therefore creating strain. Pelvic imbalance may often be corrected by raising the heel of one's shoe in such conditions as low back pain, "sciatic neuritis," lumbosacral arthritis, sacro-iliac arthritis, and arthritis of the hip and knee.

In such conditions an imbalance of the foot, ankle, and leg are very important, and may preclude a good result in spite of every other prepared remedy and measure The calf of the leg is very important and is intimately bound up with the foot and ankle in many conditions Rupture of the plantaris tendon will affect the foot and ankle to a serious degree producing disability, pain and limp It is not too far removed to discuss the psoas and abdominal muscles, the gluteal

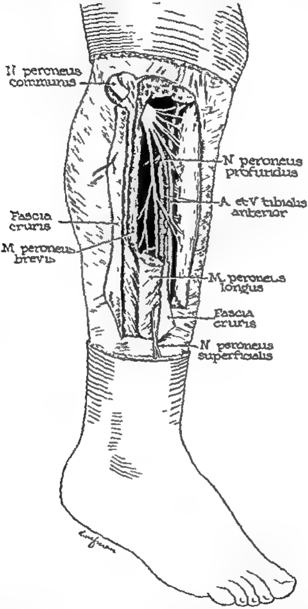


FIG 359 —Dissection of leg to show relations of external peroneal nerve

and piriformis muscles, and the tensor fasciæ latæ The fascial spaces of the thigh so accurately described by Prentiss, Milgram, and Steindler deserve the attention of everyone interested in the foot and ankle

In the treatment of leg, knee, thigh, hip and back disturbances, a foot and ankle may be put out of line, or so weakened after the origi-

CHAPTER XXXIV

THE RELATION OF BACK, PELVIS, HIP, THIGH, KNEE AND CALF TO THE FOOT AND ANKLE

It is impractical from the standpoint of function to isolate the foot and ankle from other weight-bearing structures which are in the leg, knee, thigh, hip, pelvis and lower back. There is a close relationship between foot disturbances and those of other parts of the body, especially in the hip, sacro-iliac and lumbo-sacral areas. The general health of the patient can be definitely disturbed physically and mentally by foot disturbances and painful feet. I have therefore included a short chapter bridging the gap. The anatomy of the thigh, knee and leg is shown in several accompanying illustrations. Infections of the foot and ankle may produce their first manifestations in the inguinal lymph nodes before the primary lesion is discovered.

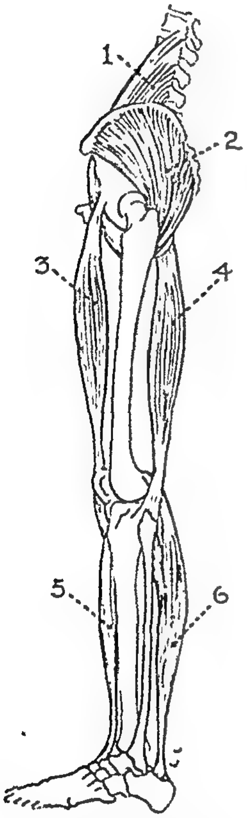


Fig. 358.—Diagram representing: 1, Iliopsoas; 2, gluteus maximus; 3, quadriceps; 4, hamstrings, 5, flexors of the ankle; 6, extensors of the ankle. (Redrawn from Mackenzie, The Action of Muscles, courtesy of Paul B. Hoeber, Inc.)

Some of the conditions occurring in the leg and thigh which have a reciprocal effect on the foot and ankle include fractures, dislocations, sprains, infections, arthritis and deformities such as bow-legs and knock-knees.

Back—Pelvis—Thigh.—A person with sway-back feels better in shoes with higher heels. A patient with flat back is able to wear low heels with comfort. The sacro-iliac joints may be seriously affected by foot disturbances, especially the mechanical ones, or painful ones which change the patient's tread, throwing the pelvis, hip and sacro-iliac joints out of balance and therefore creating strain. Pelvic imbalance may often be corrected by raising the heel of one's shoe in such conditions as low back pain, "sciatic neuritis," lumbosacral arthritis, sacro-iliac arthritis, and arthritis of the hip and knee.

In such conditions an imbalance of the foot, ankle, and leg are very important, and may preclude a good result in spite of every other prepared remedy and measure. The calf of the leg is very important and is intimately bound up with the foot and ankle in many conditions. Rupture of the plantaris tendon will affect the foot and ankle to a serious degree producing disability, pain and limp. It is not too far removed to discuss the psoas and abdominal muscles, the gluteal

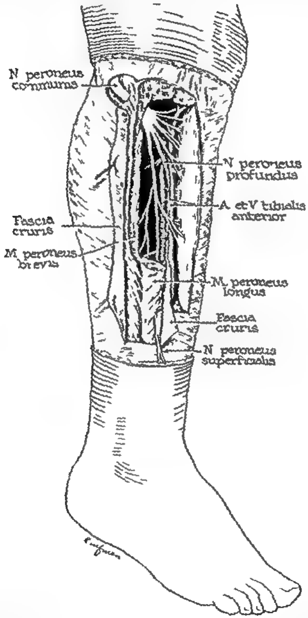


Fig. 359.—Dissection of leg to show relations of external peroneal nerve

and piriformis muscles, and the tensor fasciæ latæ. The fascial spaces of the thigh so accurately described by Prentiss, Milgram, and Steindler deserve the attention of everyone interested in the foot and ankle.

In the treatment of leg, knee, thigh, hip and back disturbances, a foot and ankle may be put out of line, or so weakened after the origi-

nal condition has been improved, that they must be treated. Following the application of braces, changes may occur in the foot and ankle which require attention or treatment. Foot strain affecting one foot and ankle from any cause may produce foot strain on the opposite side. In cases of hip, ankle, foot lesions and amputations on one side, the foot and ankle of the opposite side may be severely strained.

In 1914, Lowman called attention to the frequency with which he found points of tenderness in front of the hip joint at the point of attachment of the Y ligament and also along the posterior margin and upper angle of the greater trochanter where the piriformis and other muscles of the external rotator group are inserted. Lowman says to his patient: "There are two ends to your legs; if one end deviates, something will surely happen to the other end." In cases of simple pronation, ankle valgus, or knock-knees the inward rotation of the leg keeps the internal rotators, particularly the piriformis, on tension.

Ruptured adductor tendons are due to accidents where a person falls astride a fence or a horse. In the case of the ballet dancer, it occurs while doing the "split." Strapping the legs together is the best emergency measure.

Ruptured hamstring tendons occur chiefly in athletes and ballet dancers, due to sudden muscular activity before the tissues have been "warmed up."

Knee.—Internal and external derangements of the knees are found closely related to defects and deformities of the foot and ankle, and very often a flat-foot tends to make the medial lateral ligament and the medial semilunar cartilage more vulnerable to stress and strain. Likewise in non-operative treatment of derangements of the knee, longitudinal arch pads may favor recovery. Arthritis of the knee can be affected by mechanical defects in the foot and ankle.

Lowman has called attention to the flat-foot which occurs on the side opposite an amputation.

The best protectors of a knee are a strong quadriceps and a strong foot and ankle.

REGION OF THE HEAD OF FIBULA

The region of the head of the fibula is important in cases of tumors, deformities of the leg or tendon transplantations. Great care must be exercised in any dissection in this area due chiefly to the proximity of the peroneal nerve, a branch of the sciatic. The peroneal nerve lies between the tendon of the biceps and the outer head of the gastrocnemius muscle. The peroneus longus muscle is in close relation to the nerve. The peroneal nerve divides 1 inch below the head of the fibula into three branches: the recurrent tibial, the deep anterior tibial and the musculocutaneous or superficial branch, between the peronei and the extensor digitorum longus muscles.

There is a communication between the proximal tibiofibular joint and the knee joint, through the intermediation of the synovial prolongation subjacent to the tendon of the popliteus muscle (popliteal bursa)

The conditions which occur in the region of the head of the fibula are chiefly fractures, dislocations, subluxations, arthritis and tumors

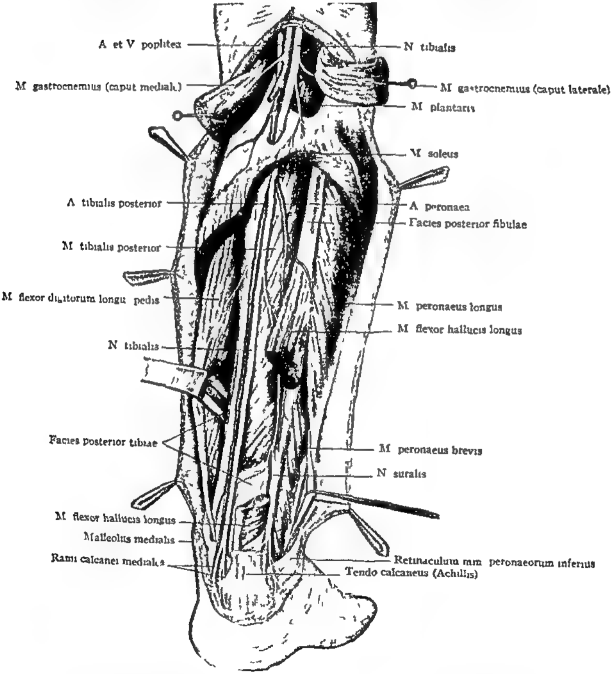


FIG 360 —Vessels nerves and deep musculature of the posterior region of the leg Much of the gastrocnemius and soleus muscles has been removed (Callander Surgical Anatomy courtesy of W B Saunders Company)

nal condition has been improved, that they must be treated. Following the application of braces, changes may occur in the foot and ankle which require attention or treatment. Foot strain affecting one foot and ankle from any cause may produce foot strain on the opposite side. In cases of hip, ankle, foot lesions and amputations on one side, the foot and ankle of the opposite side may be severely strained.

In 1914, Lowman called attention to the frequency with which he found points of tenderness in front of the hip joint at the point of attachment of the Y ligament and also along the posterior margin and upper angle of the greater trochanter where the piriformis and other muscles of the external rotator group are inserted. Lowman says to his patient: "There are two ends to your legs; if one end deviates, something will surely happen to the other end." In cases of simple pronation, ankle valgus, or knock-knees the inward rotation of the leg keeps the internal rotators, particularly the piriformis, on tension.

Ruptured adductor tendons are due to accidents where a person falls astride a fence or a horse. In the case of the ballet dancer, it occurs while doing the "split." Strapping the legs together is the best emergency measure.

Ruptured hamstring tendons occur chiefly in athletes and ballet dancers, due to sudden muscular activity before the tissues have been "warmed up."

Knee.—Internal and external derangements of the knees are found closely related to defects and deformities of the foot and ankle, and very often a flat-foot tends to make the medial lateral ligament and the medial semilunar cartilage more vulnerable to stress and strain. Likewise in non-operative treatment of derangements of the knee, longitudinal arch pads may favor recovery. Arthritis of the knee can be affected by mechanical defects in the foot and ankle.

Lowman has called attention to the flat-foot which occurs on the side opposite an amputation.

The best protectors of a knee are a strong quadriceps and a strong foot and ankle.

REGION OF THE HEAD OF FIBULA

The region of the head of the fibula is important in cases of tumors, deformities of the leg or tendon transplantations. Great care must be exercised in any dissection in this area due chiefly to the proximity of the peroneal nerve, a branch of the sciatic. The peroneal nerve lies between the tendon of the biceps and the outer head of the gastrocnemius muscle. The peroneus longus muscle is in close relation to the nerve. The peroneal nerve divides 1 inch below the head of the fibula into three branches: the recurrent tibial, the deep anterior tibial and the musculocutaneous or superficial branch, between the peronei and the extensor digitorum longus muscles.

There is a communication between the proximal tibiofibular joint and the knee joint, through the intermediation of the synovial prolongation subjacent to the tendon of the popliteus muscle (popliteal bursa)

The conditions which occur in the region of the head of the fibula are chiefly fractures, dislocations, subluxations, arthritis and tumors

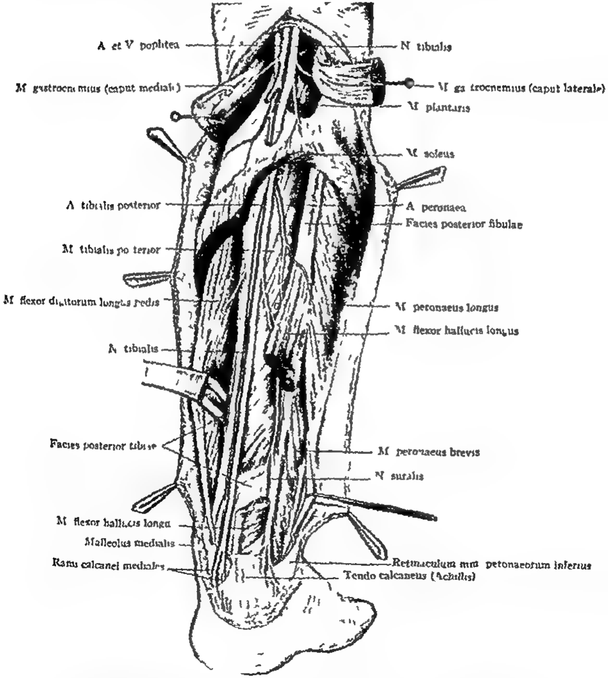


FIG 360 —Vessels, nerves, and deep musculature of the posterior region of the leg Much of the gastrocnemius and soleus muscles has been removed (Callander, Surgical Anatomy courtesy of W B Saunders Company)

The head of the fibula can be removed without causing serious functional disability.

There are two routes of approach to the head of the fibula, *viz.*, a lateral incision and a posterolateral incision.

In all important operations in this region it is advisable to isolate the external popliteal nerve and retract it very gently by means of a strip of tape soaked in normal saline solution. The ends of the tape are secured by an artery snap. The assistant who holds it must be warned of the danger of producing a physiological interruption of continuity of nerve function by traction or pressure neuritis. The situation is similar to that of the ulnar nerve in the medial humeral epicondylar groove.

LEG CRAMPS

Leg cramps may occur during the day or night, diurnal or nocturnal. (Diurnal leg cramps are considered under intermittent claudication on page 585.) The pains of intermittent claudication, which are characteristically induced by uninterrupted walking, disappear promptly on cessation of activity. They do not occur while the patient is at rest or as a result of prolonged periods of standing or of interrupted walking of short distances, as illustrated by the activity of a clerk in a store.

If pulsations in the dorsalis pedis, posterior tibial and popliteal arteries are normal, the pain is not due to intermittent claudication. The symptoms may be evidence of a general exhaustion state such as neurasthenia or chronic nervous exhaustion. The patient may have peripheral neuritis due to lead, arsenic diabetes, or vitamin deficiency or he may have an inflammatory lesion or compression of the lumbosacral plexus. Arthritis of the spine may be responsible.

The teeth, tonsils and prostate gland should be examined for evidence of infection, which should be eradicated if present.

Nocturnal leg cramps occur only during sleep. A person may be roused from a sound sleep with excruciating pain in one or both calf muscles. He rises, tries to stretch his legs, "points" his toes, massages his calf muscles or touches a cold object and the pain gradually wears off, but the sensitiveness and discomfort may persist for twenty-four hours. Various explanations have been offered for this phenomenon. Compression of the popliteal vessels or nerve or the leg in a cramped position is a factor. Another theory ascribes them to a difference in oxygen tension in the blood which is determined by the degree of humidity and the oxygen content of the air in the sleeping room.

Lewis believes that the direct cause may be exposure to chilling. The cramping is not the result of withdrawal of blood from the capillaries but is thought to be a vasomotor reaction, initiated by nerve

impulses brought about by chilling When muscles have been driven until they are exhausted and have used up their reserves they are liable to cramp if forced further If they are driven after they have used up their salt supply there is a reaction which takes the form of cramping

Pain in the calves of the legs may be due to arterial disease

Muscle spasm occurring with fatigue suggests that it may be on the basis of calcium deficiency of mild grade Muscle cramps might occur as a result of overactivity, a stimulation similar to that following fatigue with but slight impairment of the blood supply

It is not often necessary to differentiate nocturnal leg cramps from the night cries due to bone pain because the former occur chiefly in adults Children, however, have cramps in the legs at night but they are often due to pronated feet

The condition is common It seems to be preponderately present in middle life and older age Nearly all the patients have varicose veins Diabetes does not seem to be a factor Many patients volunteer the information that they are more prone to have cramps during a night following a day when they were on their feet excessively or when they had an unusually hard day's work

Cramp of the Calf Muscles —This familiar cramp is described by Hunter as follows Half awake in the morning one lazily stretches out and is suddenly seized in one calf with a very painful cramp which lasts about a minute, during which the tendo Achillis is powerfully contracted drawing the forepart of the foot downwards If one palpates the calf during the cramp, one is astonished to feel, owing to the intense muscular spasm, a deep ridge at the junction of the muscular and tendinous portions of the calf muscles In some people, this condition may return morning after morning and with a restless night may recur more than once A physician stated that a man suffered repeatedly from this cramp while pulling on heavy overshoes Twice he was consulted because of its occurrence during sexual intercourse

It is usually easy to prevent its occurrence, one deliberately avoids stretching the foot on waking—one resists the inclination to bring the toes down and heel up for a moment or two after awakening Tight bedclothes at the foot of the bed may have something to do with this tendency, a long pillow at the foot is useful in preventing involuntary overstretching In obstinate cases, where dorsi-extension of the ankle occurs in the half-sleepy state, uncontrolled by consciousness and where therefore the cramp itself awakens the sleeper, a special shoe has been made for night wear, to prevent involuntary stretching

Cramps of the calf muscles are ascribed to prolonged overexertion and to diabetes, alcoholism, and uremia Many patients learn that they can get rid of the cramp at once if they forcibly dorsiflex their foot with their hand or touch a cold object

Muscle cramps occurring during sleep appear to arise in the same manner as do those which follow stretching except that the primary muscle contraction is an involuntary or sleep movement in the former instance and voluntary in the latter instance. In swimming, the inhibiting effect of the cold on the peripheral circulation contributes to the disposition to cramps, probably by interference with the normal metabolism of muscle.

The treatment during the episode is the forced manual extension of the muscle involved by the cramp. If for example, the muscles of the calf are involved, the foot should be forcibly dorsiflexed. Prevention of the episodes is usually simple; avoidance of unopposed muscular contraction as during a stretching and of swimming in cold water by those having a predisposition to cramps. Individuals who suffer during the sleeping hours should be fitted with a special sheet to prevent involuntary muscle contraction. If the aforementioned plan of treatment is unsuccessful, the administration of some of the acid forming salts, as ammonium nitrate, at bedtime may be helpful. The assumption is that the salt prevents the tendency to alkalosis, to which the neuromuscular mechanism is unduly sensitive.

During years of practice, especially with diabetic patients Mills found that from 10 to 15 drops of dilute hydrochloric acid in water, with each meal, will completely relieve most cases within a day or two. When intestinal putrefaction is present, to augment the alkalosis by absorption of the alkaline amines, kaolin finely suspended in syrup is given in addition to the acid.

Moss and Herrmann find that spasms in the muscles of the extremities that occur during the night are amenable to treatment by means of quinine sulfate. This is given in capsules of 3 grains each, three times a day. It is thought to act at the myoneural junction, and appears to be the pharmacological antagonist of prostigmine, thereby relieving the muscle spasm.

Steven reported good results following the use of calcium gluconate administered two or three times daily before meals.

Night Cramps in Young Men.—Nicholson and Falk present observations on 23 of these cases. The average age of the soldiers was twenty-five years. A person with night cramps is usually free from symptoms during the day, whether resting or walking. He retires without symptoms but is awakened by a cramping pain usually in the calf muscles, although any muscle group in the lower extremity may be involved. Muscle groups in other parts of the body are rarely affected. Vigorous rubbing of the leg or hopping about gradually relaxes the muscles but there is often residual soreness lasting for hours. In the treatment of night cramps these authors used quinine sulfate. More than a fourth of their patients failed to obtain relief. The majority of those who

obtained relief required a number of doses The effect of this drug is short lived and not cumulative Patients have relief for many days and not infrequently for weeks after ceasing medication The most frequent disorder predisposing to night cramps was static foot deformity Orthopedic appliances often give relief of foot symptoms without change in the occurrence of night cramps In none of the patients was

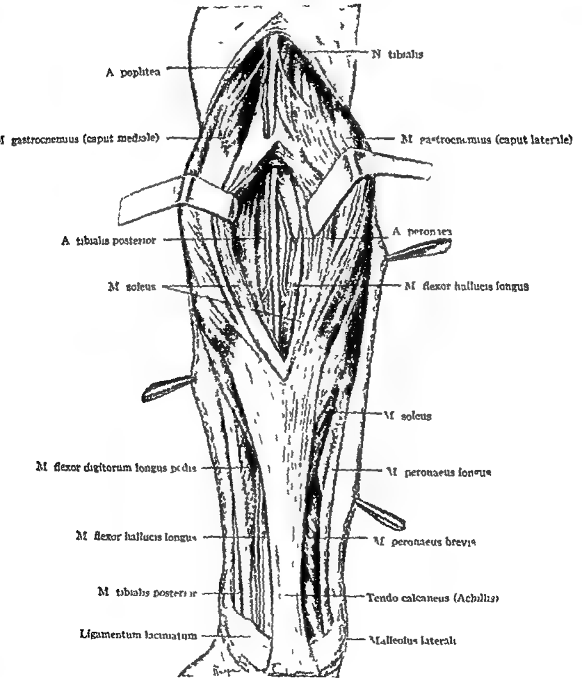


FIG 361 — Superficial structures in the posterior region of the leg The bellies of the gastrocnemius are separated and the soleus muscle is split to show the vessels and nerves in the deep muscle layers (Callander Surgical Anatomy courtesy of W B Saunders Company)

there found any peripheral arterial disease, although in 2 cases there was old deep thrombophlebitis of the lower extremities.

Nocturnal Cramps in the Legs.—Standlee relieved 3 patients by means of alkaline catharsis, *i. e.*, small doses of sodium phosphate every morning. Before retiring they alternately placed each foot on the opposite thigh, while sitting on a chair, thus relaxing them and passively manipulating all the toes and metacarpal joints and the ankle. They did this quite vigorously. This causes a local congestion and an increase of the blood supply in this area. It also stimulates the nerve endings here.

Thiamine Hydrochloride for Cramps in Legs.—Block found that the use of sufficient amounts of vitamin B_1 (10 to 30 mg. daily) will relieve the leg cramps not only in the pregnant but in the majority of other patients that have them. However, it has to be administered parenterally in some cases.

I have found the following to be very successful—unless the attack has gone on for several minutes. As soon as the pain and spasm half wakens the subject, he should perform the movements of bicycling very rapidly for one or two minutes. He will find that the attack is aborted and that the calf muscle soreness will not persist.

The "attack" can be cut short or prevented by stepping on a cold surface, the bedroom or bathroom floor.

It is a fact that a person can "condition" himself to waken before the cramp becomes full blown.

The "Charley horse" usually occurs during physical activity.

Some other important lesions involving the calf are thromboangiitis obliterans, poliomyelitic paralysis, spastic paralysis, pseudohypertrophic muscular dystrophy and tumors of the muscles, bloodvessels, and bones.

ISCHEMIC CONTRACTURE OF THE LOWER EXTREMITY

Horwitz[1] reported 2 cases of ischemic contracture involving the lower extremities and reviewed the 18 previously reported cases in the literature. The 2 new cases were of eleven and fourteen years duration and presented the following features: (1) healed fractures of the femur; (2) massive induration of the muscles of the leg and foot associated with atrophy and loss of motor power below the knee; (3) vascular dysfunction in the involved lower extremity; (4) contractural deformities of the foot and toes; (5) roentgen evidence of extra-osseous calcification of the leg; and (6) histological evidence (in 1 case) of massive degeneration of muscle tissue with fibrous-tissue replacement and extensive calcification. In these cases there was a pathological

Horwitz, T., Arch Surgery, 1940

state in the lower extremity identical with Volkmann's ischemic contracture of the upper extremity

Its occurrence must be anticipated after fracture or extensive injury to the soft tissues without fracture, especially in the region of the knee and leg The stage of contracture and deformity may be avoided by fasciotomy during the acute (prodromal) stage Deformities of the lower extremity consequent on the contractures may be corrected by adequate non-operative and operative measures The wisdom of fasciotomy during the acute stage, in the lower extremity as in the upper extremity appears to be substantiated by the recovery and the avoidance of contractual deformities in the case reported by Jones and Cotton, after exposure of the popliteal space and evacuation of its extravascular bloody contents If the contracture is to be avoided, pressure must be relieved immediately, as soon as the earliest evidence of impending vascular interference becomes recognizable

Extra-osseous calcification representing the dystrophic form of pathological calcification is characterized by the deposit of lime salts in tissue of low viability or in dead tissue Available evidence indicates that this process is associated with vascular deficiency and is dependent on local factors such as the hydrogen-ion concentration and carbon-dioxide tension

The clinical features of the acute stage are pain, cyanosis, edema, paresthesia, hypesthesia loss of motor power, and trophic disturbances In the residual stage the muscles become rigid and contracted, an equinus deformity develops, cavus and varus deformities of the foot occur, and there are multiple hammer-toe contractures

Albert and Mitchell reported 3 cases in which there was ischemia of the anterior tibial group of muscles of the leg along with vascular injury As a result of the ischemia and vascular injury there was foot drop, calcification, and abscess formation The ischemia is described as being of the Volkmann type The harmful result of a skin tight plaster cast is stressed, as well as the importance of early surgical treatment if arterial occlusion is diagnosed The calcification and abscesses may require surgical intervention

ACUTE ISCHEMIA OF THE ANTERIOR TIBIAL MUSCLE AND THE LONG EXTENSOR MUSCLES OF THE TOES

A peculiar type of vascular disturbance localized to the anterior fascial compartment of the leg, has been observed by Horn in young healthy soldiers No acute trauma has been associated with the onset of such disturbance The following conditions have been considered and eliminated in the differential diagnosis, emboli, aneurysm, Raynaud's disease, thrombo-angiitis obliterans, arteriosclerosis, periarter-

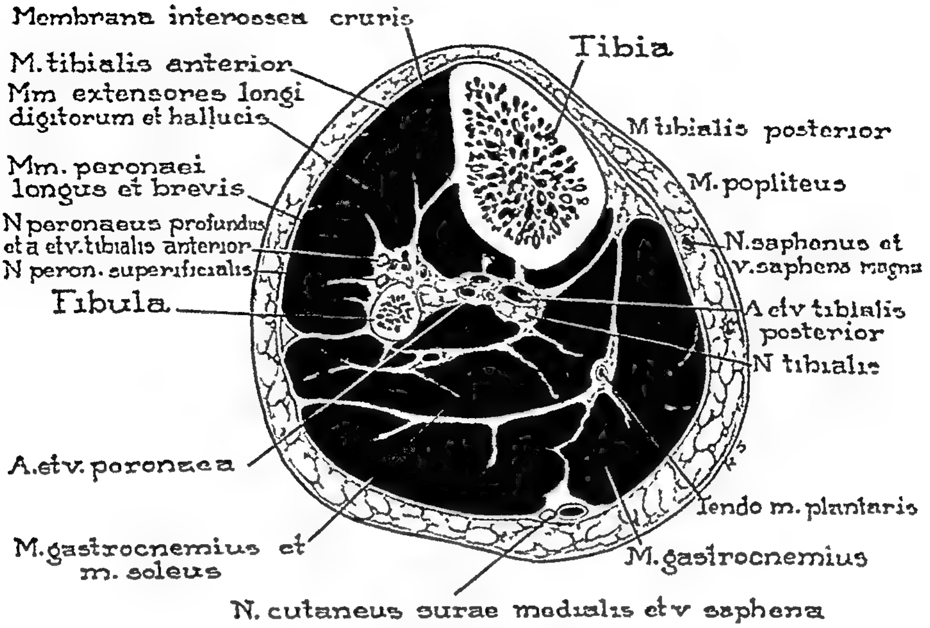


Fig. 362.—Cross-section of the leg at the level just inferior to the formation of the peroneal artery. (Modified by Horn, from Eycleshymer and Shoemaker's Cross-section Anatomy; courtesy of D. Appleton Century Company.)

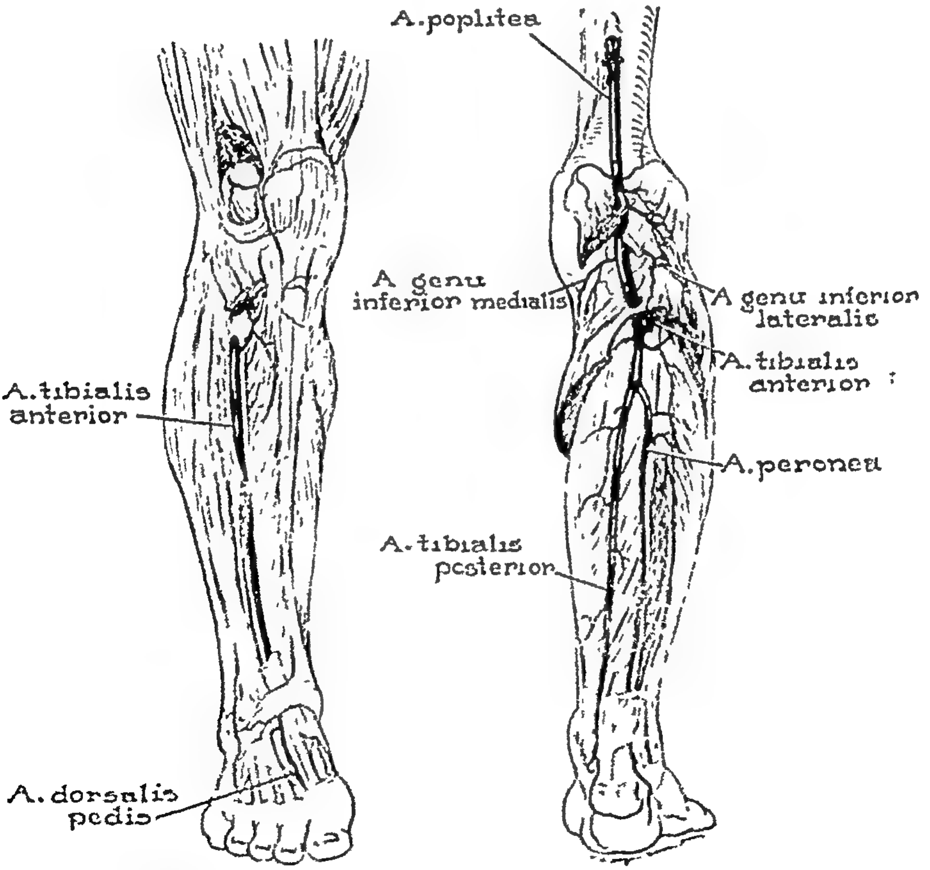


Fig. 363.—Arteries of the leg. (Modified by Horn, from Hand Atlas of Human Anatomy by Spalteholz, courtesy of J. B. Lippincott Company.)

itis nodosa, peritendinitis crepitans, phlebitis, cellulitis, fibrositis, rheumatoid arthritis, anterior poliomyelitis, myositis due to bacteria or parasites, and tumors of the muscle The characteristic clinical symptoms and findings are as follows

1 Sudden onset of severe pain in the anterior portion of the leg

2 Rapid development of swelling that is most marked over the anterior fascial compartment

3 Mild to intense erythema and glossiness over the anterior fascial compartment

4 Slight to complete interruption of function of the common peroneal nerve

Sirbu, Murphy, and White described ischemia of the anterior tibial muscle in 2 soldiers In one, the ischemia developed following repair of a hernia of a small muscle and in the other, ischemia of the anterior tibial muscle of both legs followed a march These writers believe that there is a direct relationship between excessive marching and circulatory disturbances in the anterior tibial muscle

Howard studied the chemical and histological changes in the muscles of patients having peritendinitis crepitans This condition develops when individuals perform certain repeated, rapid motions to which they are unaccustomed, or when they continue to use a muscle that has suffered a direct trauma

The primary pathological change is exhaustion of the muscle, with retention of lactic acid, and a depletion of muscle glycogen Histologically the venules are thrombosed, all tissues are edematous, hemorrhage is present in areolar tissue and muscle, and fibrin is deposited about the peritenon in clumps The muscle fibers have lost their cross-striations, and they may be hyalinized in mild cases or they may be necrotic in severe cases

Horn's conclusions were 1 The syndrome of localized ischemia of the anterior tibial muscle and long extensor muscles of the toes presents a definite entity

2 The essential vascular change is a fibrosis of the media, adventitia, and periarterial tissue of the anterior tibial artery, with ensuing occlusion

3 The histological changes in the affected muscles are identical to those occurring in Volkmann's ischemia

4 The pathogenesis may be explained by repeated overwhelming physiological demands upon the anterior tibial artery, such as occur in long periods of training in the infantry, and in athletics

5 The acute onset of severe ischemia during marching is probably due to muscular exhaustion, and swelling in the anterior fascial compartment

6 The musculature of the anterior fascial compartment is par-

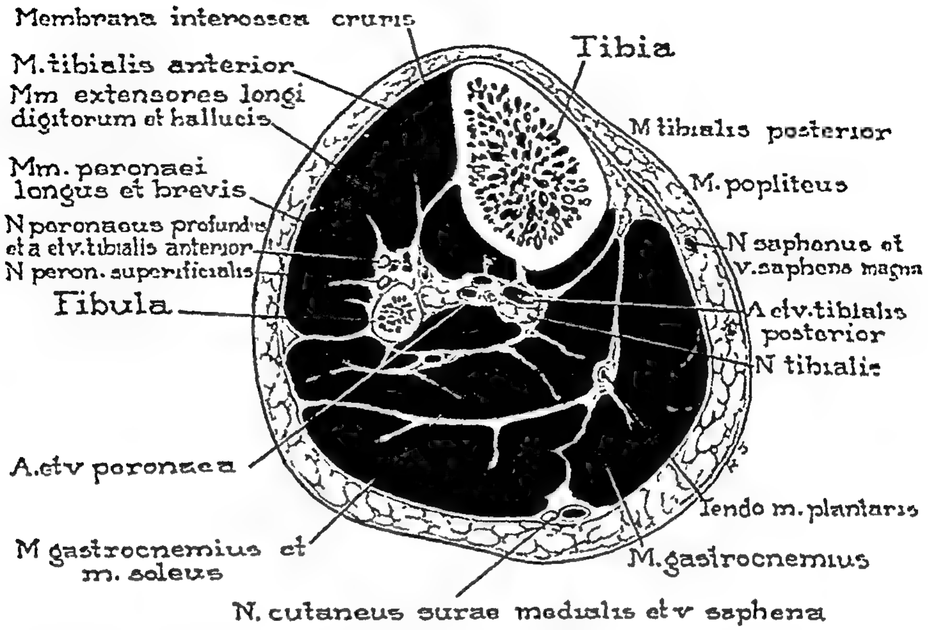


FIG 362.—Cross-section of the leg at the level just inferior to the formation of the peroneal artery. (Modified by Horn, from Eycleshymer and Shoemaker's Cross-section Anatomy; courtesy of D. Appleton Century Company)

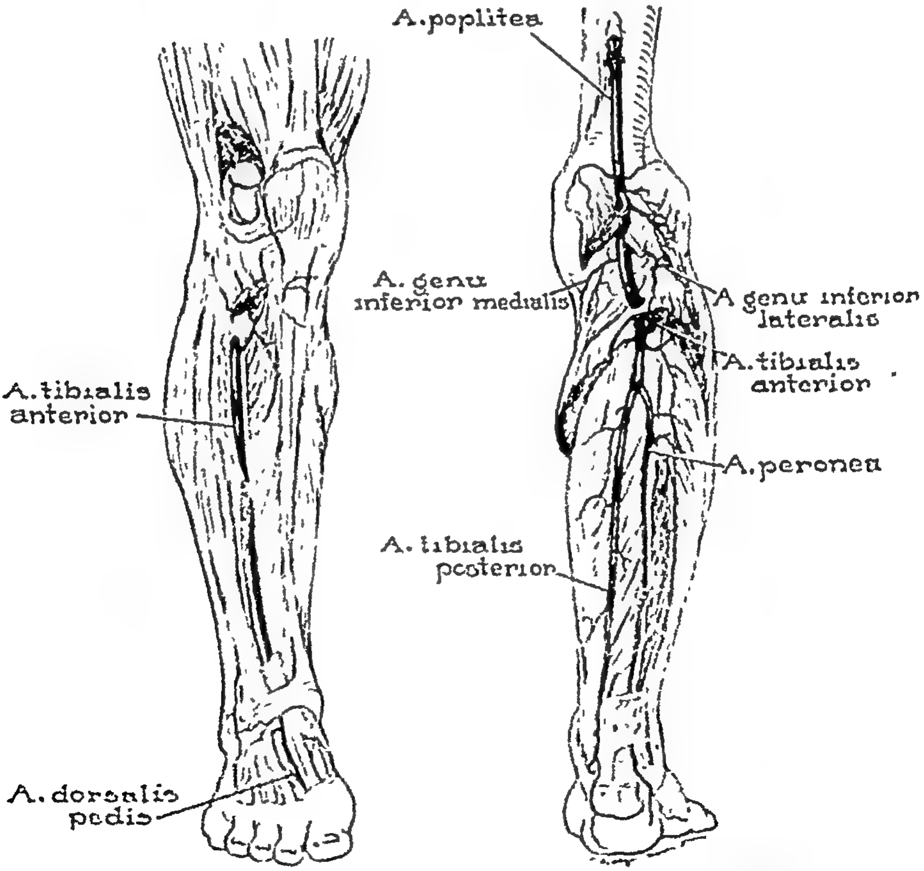


FIG. 363.—Arteries of the leg. (Modified by Horn, from Hand Atlas of Human Anatomy by Spalteholz, courtesy of J. B Lippincott Company.)

itis nodosa, peritendinitis crepitans, phlebitis cellulitis fibrositis, rheumatoid arthritis, anterior poliomyelitis, myositis due to bacteria or parasites, and tumors of the muscle The characteristic clinical symptoms and findings are as follows

1 Sudden onset of severe pain in the anterior portion of the leg

2 Rapid development of swelling that is most marked over the anterior fascial compartment

3 Mild to intense erythema and glossiness over the anterior fascial compartment

4 Slight to complete interruption of function of the common peroneal nerve

Sirbu, Murphy, and White described ischemia of the anterior tibial muscle in 2 soldiers In one, the ischemia developed following repair of a hernia of a small muscle and in the other, ischemia of the anterior tibial muscle of both legs followed a march These writers believe that there is a direct relationship between excessive marching and circulatory disturbances in the anterior tibial muscle

Howard studied the chemical and histological changes in the muscles of patients having peritendinitis crepitans This condition develops when individuals perform certain repeated, rapid motions to which they are unaccustomed, or when they continue to use a muscle that has suffered a direct trauma

The primary pathological change is exhaustion of the muscle, with retention of lactic acid, and a depletion of muscle glycogen Histologically the venules are thrombosed, all tissues are edematous, hemorrhage is present in areolar tissue and muscle, and fibrin is deposited about the peritenon in clumps The muscle fibers have lost their cross-striations, and they may be hyalinized in mild cases, or they may be necrotic in severe cases

Horn's conclusions were 1 The syndrome of localized ischemia of the anterior tibial muscle and long extensor muscles of the toes presents a definite entity

2 The essential vascular change is a fibrosis of the media, adventitia, and periarterial tissue of the anterior tibial artery, with ensuing occlusion

3 The histological changes in the affected muscles are identical to those occurring in Volkmann's ischemia

4 The pathogenesis may be explained by repeated overwhelming physiological demands upon the anterior tibial artery, such as occur in long periods of training in the infantry, and in athletics

5 The acute onset of severe ischemia during marching is probably due to muscular exhaustion, and swelling in the anterior fascial compartment

6 The musculature of the anterior fascial compartment is par-

ticularly vulnerable to circulatory disturbances because of the anatomical arrangement.

7. Early block of the lumbar sympathetic ganglia and early complete vertical incision of the anterior fascia cruris improve the collateral circulation, and permit the return of function to the common peroneal nerve.

8. Arteriectomy is indicated, if segmental arterial spasm persists or if arterial occlusion is present.

9. Idiopathic claw-foot may be the result of insufficiency of the anterior tibial artery with ischemic contracture of the anterior tibial muscle and long extensor muscle of the toes.

RESTLESS LEGS

The syndrome described by Ekbom occurs not infrequently in patients with nutritional deficiency and clears up more or less promptly under intensive therapy with the vitamin B factors (including an adequate natural source of the B complex). Biskind believes the disturbance is apparently part of the general phenomenon of hyper-irritability of the nervous system which occurs in deficiency of thiamine and niacinamide, and of other as yet unidentified nutritional factors.

Various reports on the condition sometimes referred to as "jittery" or "restless" legs are reviewed in *The British Medical Journal*, January 19, 1946 and February 23, 1946. The symptoms are those of pain, aching, discomfort, or dysesthesia or a crawling or tingling, pins-and-needles character, deep in the leg, usually the calf, and sometimes the feet. They come on especially at night, often causing the patient to lose sleep. Temporary relief is obtained by moving the legs, walking about or rubbing the feet. There is no objective coldness or discoloration, and pulsation is reported to be normal. Onset seemed to be associated with states of anxiety and overwork. Severe cases were somewhat commoner in women then in men. Some reports suggest that this is a disorder of the peripheral circulation; others that a vicious cycle is set up between organic vasomotor disturbance and psychogenic factors. Effective treatment has included barbiturates, aspirin, reduction of cigarette smoking, anti-anemic therapy, nitroglycerin, vasodilating substances, and elevation of the foot of the patient's bed.

"SHIN SPLINTS"

The term shin splints is used by athletes, especially track men. The condition is probably due to myositis of the tibial and toe extensor muscles. It may be tendonitis, myositis, or myofascitis with an element of periostitis. It is usually due to multiple minimal traumas, such as

occur in tapping against hard surfaces such as a track, a cement floor or a hard wood floor in a gymnasium It may be due to repeated sudden starts and stops

In nearly every athletic pursuit one leg is subject to more shocks than the other

A roentgenogram of the tibia would rule out periostitis or any other lesion, including a neoplasm

While at the University of Chicago, in charge of the medical supervision of athletic teams, Molander saw many such injuries, and in the majority of instances they were in track athletes They also occurred in football and basketball players

The early diagnosis of the condition is sometimes difficult In the great majority of instances the athlete states that he has a dull aching pain over the anterior surface of the middle and lower thirds of the tibia and fibula and that he finds it hard to raise the heel from the floor without experiencing a sharp pain over the area described Shin splints occur as a rule early in the season and in the majority of cases are caused by running on a hard board surface which produces constant jarring

The patients are slow in recovering

The most noticeable symptom is severe tenderness over the anterior surface of the lower and middle thirds of the tibia and fibula This area feels hard and tense Support by means of circular taping seems to give relief Molander attributed this condition either to a tearing of the origin of the dorsiflexors of the foot or to a severe tendon strain The former explanation seems the more plausible because of the persistent aching pain, which becomes intensified while one stands on the toes, and because of the long recovery period

In treatment Molander employed a circular adhesive strapping and additional long strips of tape from the knee and around the ankle, keeping it at a right angle After twenty-four hours the involved extremity is placed in the whirlpool bath at 105° or 110° F for at least half an hour Then the part is dried with infra-red radiation while the ankle is maintained at a right angle Drying is followed with massage of the entire extremity, the tender areas being avoided When tenderness has disappeared a graduated system of therapeutic exercises is used getting the patient to an upright position for athletic work when function of the foot has returned to normal This may take weeks or even several months

Pipkin called attention to a considerable number of cases he considered to be due to improper ankle support Average persons between the ages of thirty-five and fifty-five who engage in games like paddle tennis, handball, badminton and squash are adapted to the ordinary heel of a street shoe and when they resume competitive sports they

are not elastic enough to adjust themselves to the flat heelless tennis or basketball shoe without some evidence of strain. Treatment of this disability consists of a good lace, high top basketball shoe. Half-inch sponge rubber lifts should be worn underneath the heels until the patient finds he can play without symptoms. Ankle wraps should be worn by any adult playing a vigorous competitive game and having any type of leg symptoms. The majority of professional athletes in their prime wear ankle wraps, yet the occasional athlete will not take the trouble to use them. Pipkin advises an ankle wrap made of a 2-inch wide linen bandage, 5 yards in length, wrapped in a figure of eight manner about the ankle. He does not consider these leg aches to be a contraindication to exercises.

SUBCUTANEOUS RUPTURE OF THE TENDON OF THE TIBIALIS ANTICUS

Burman added 2 cases of subcutaneous rupture of the tendon of the tibialis anticus to the two that had been recorded.

The simplest treatment is the suture of the torn tendon, which is followed by a perfect end-result. The tendon ends should be united intrathecally by a strong tendon suture. The foot is put in plaster in dorsiflexion and inversion for a few weeks. A month after operation, Bruning's patient had full use of the tendon and six months later could go mountain climbing. Mayer's patient had a 75 per cent return of power five weeks after operation. Five years later the foot was normal.

Tears of other tendons of the foot, except those of the tendo Achillis and of the tendon of the plantaris are equally rare. Camitz (quoted by von Stapelmohr) reported an old tear of the tibialis posticus with a gap of 8 centimetres between the tendon ends. This was successfully bridged by a strip of fascia lata several years after the actual tear. Tears of the extensor tendons of the toes apparently have not been reported. Meyer noted a fraying of the peroneus brevis tendon in a cadaver but rupture had not taken place.

PATHOLOGY OF RUPTURED PLANTARIS

Jones' case report reveals that actual rupture of the belly of the plantaris muscle does occur. His case shows that sometimes at least the symptoms are produced by rupture of the plantaris muscle

The plantaris is absent in 7.5 per cent of subjects according to Gruber. Pilcher found the muscle absent or rudimentary in 16 of 100 consecutive postmortem examinations, and states that the deficiency is more common in women than in men. The frequency of occurrence

of the plantaris muscle is thus compatible with its presence in every case showing the classical clinical picture of rupture

Greater tension per unit area is developed in the plantaris on forced dorsiflexion of the ankle than in the other calf muscles, because the length of the plantaris belly is only one-fifth of the total length of muscle and tendon, whereas one-half of the total length of the soleus and gastrocnemius is composed of muscle fibers

It seems reasonable to postulate, therefore, that in healthy tissues the sequence of events in increasingly violent dorsiflexion of the ankle is (1) partial tear of the plantaris, (2) complete tear of the plantaris, (3) rupture of the other calf muscles in addition or the tendo Achilles

The weakest part of the muscle is its contractile fibers

The site of tenderness in 8 cases of "ruptured plantaris" was over the plantaris muscle belly This is strong evidence pointing to the muscle itself as the site of the lesion

The lesion described as "ruptured plantaris" is in fact a partial or complete tear of the fleshy fibers of the plantaris muscle

The anatomical features of a short muscle belly and a long tendon cause this muscle to be subjected to greater tension than the other calf muscles

The weakest part of the muscle is its belly

CONGENITAL ABSENCE OF TIBIA

In congenital absence of the tibia, the fibula has been transplanted to take the place of the missing tibia by a two stage operation which was recommended by Wilson and several others, where one end of the fibula is transplanted and several weeks later the other end, resulting in a complete substitution of the unimportant fibula for an important tibia

Transplantation of the Fibula to Replace the Tibia—Badgley outlines the following requirements for the two stage operation a normal fibula, with a gap in the tibia, but both epiphyses of the tibia normal, all sinuses must be healed and no evidence of infection for at least six months, free motion of ankle and of knee must be present, the tissue over the old infected area should stand pounding and rough treatment for several days without lighting up the infection The graft is never a free graft as union at one end is maintained at all times Its own blood supply from both the nutrient vessel and from the subperiosteal vessels in part is maintained It is thus much more resistant to infection and does not sequestrate as does a free graft It has the property of growth in response to its new function A successful result from the two stage fibular transplant is practically assured There is complete restoration of function in an otherwise useless or badly crippled leg

RUPTURES OF THE MUSCLES AND TENDONS OF THE CALF OF THE LEG

Ruptures of the calf may involve the gastrocnemius, soleus and plantaris muscles and tendons. They occur especially during exercises and athletics. They may occur in tennis players or following any sudden muscular effort such as running for a street car or train. An important factor is the sudden activity of muscles that are "cold." One of my

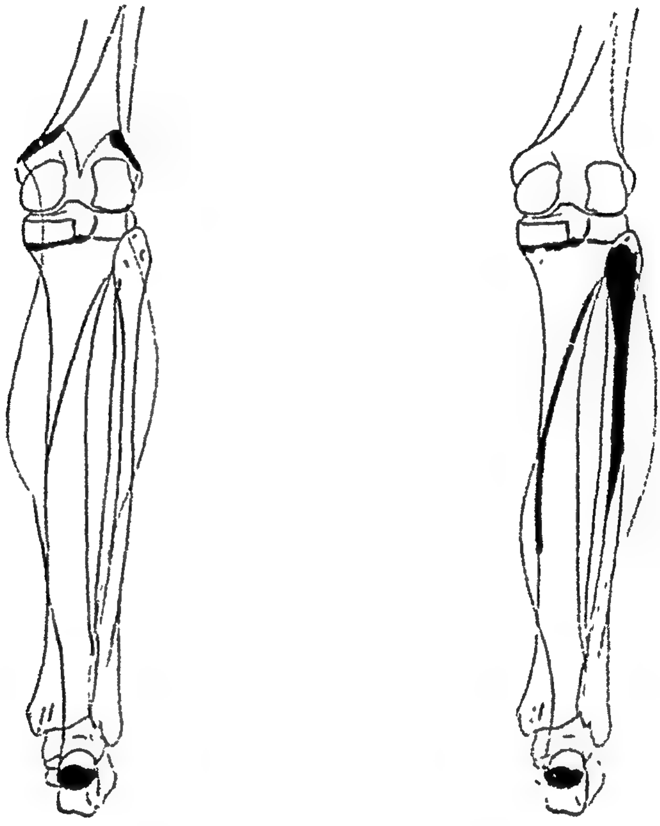


FIG. 364 FIG. 365

FIGS. 364 and 365.—The combined soleus and gastrocnemius is called the calf muscle.
FIG. 364.—The gastrocnemius of right side; outline and attachment areas.
FIG. 365.—The soleus of right side; outline and attachment areas.

patients was sitting in a room when the telephone rang and without putting her shoes on ran into the other room where the telephone rang. After two or three steps she suffered pain in her calf and was unable to get to the phone. When examined she had a swollen, discolored, tender calf which was due to a rupture of part of the medial portion of the gastrocnemius. In the typical case a sudden move such as is made in starting to run up an incline is followed by lancinating pain so severe as to suggest the impact of a baseball bat or a golf ball.

The symptoms are chiefly pain and tenderness due to the tear which causes hemorrhage

The pathological change is usually a rupture of the plantaris tendon or a certain degree of avulsion of the Achilles tendon from the muscles of the calf group

Examination reveals localized pain, limited movement in certain directions and inability to walk or rise on the toes comfortably

Fig 366

Fig 367

Fig 368

Figs 366 and 367 —The direct dorsal flexors
Fig 366 —Tibialis anterior of right side outline and attachment areas
Fig 367 —Peroneus tertius of right side outline and attachment areas
Fig 368 —The most important adductor Tibialis posterior of right side outline and attachment areas Most of the muscle of the foot are represented as if seen through the bones

The roentgenogram is usually negative but may reveal soft tissue shadow due to hemorrhage

Cold should be applied immediately and the foot placed in a moderate equinus position with the knee flexed Strapping and a raised heel to relax the calf group are helpful The best treatment is the application of a plaster cast maintaining the toe-drop position Such a cast with a walking iron permits the patient to walk without causing pressure or strain on the injured tissues After ten days in the cast massage and heat, inductotherm, and a raised heel are prescribed An elastic

RUPTURES OF THE MUSCLES AND TENDONS OF THE CALF OF THE LEG

Ruptures of the calf may involve the gastrocnemius, soleus and plantaris muscles and tendons. They occur especially during exercises and athletics. They may occur in tennis players or following any sudden muscular effort such as running for a street car or train. An important factor is the sudden activity of muscles that are "cold." One of my

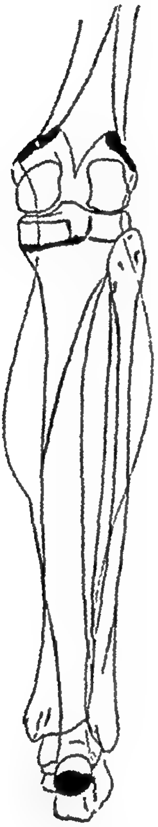


Fig. 364

Fig. 365

Figs 364 and 365 —The combined soleus and gastrocnemius is called the calf muscle
Fig. 364.—The gastrocnemius of right side, outline and attachment areas
Fig 365 —The soleus of right side, outline and attachment areas.

patients was sitting in a room when the telephone rang and without putting her shoes on ran into the other room where the telephone rang. After two or three steps she suffered pain in her calf and was unable to get to the phone. When examined she had a swollen, discolored, tender calf which was due to a rupture of part of the medial portion of the gastrocnemius. In the typical case a sudden move such as is made in starting to run up an incline is followed by lancinating pain so severe as to suggest the impact of a baseball bat or a golf ball.

The symptoms are chiefly pain and tenderness due to the tear which causes hemorrhage

The pathological change is usually a rupture of the plantaris tendon or a certain degree of avulsion of the Achilles tendon from the muscles of the calf group

Examination reveals localized pain, limited movement in certain directions and inability to walk or rise on the toes comfortably

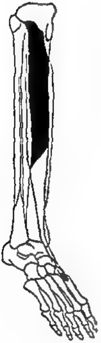


Fig 366

Fig 367

Fig 368

Figs 366 and 367 —The direct dorsal flexors

Fig 366 —Tibialis anterior of right side outline and attachment areas

Fig 367 —Peroneus tertius of right side outline and attachment areas

Fig 368 – The most important adductor Tibialis posterior of right side outline and attachment areas Most of the muscle of the foot are represented as if seen through the bones

The roentgenogram is usually negative but may reveal soft tissue shadow due to hemorrhage

Cold should be applied immediately and the foot placed in a moderate equinus position with the knee flexed Strapping and a raised heel to relax the calf group are helpful The best treatment is the application of a plaster cast maintaining the toe-drop position Such a cast with a walking iron permits the patient to walk without causing pressure or strain on the injured tissues After ten days in the cast, massage and heat, inductotherm, and a raised heel are prescribed An elastic

stocking is very helpful. Healing usually requires from four to six weeks.

Fig 369

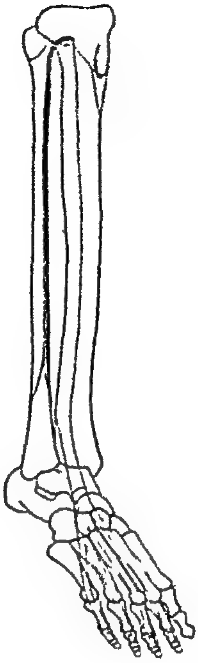


Fig. 370

Fig. 369.—Extensor proprius hallucis of right side; outline and attachment areas.
Fig. 370—Extensor longus digitorum of right side; outline and attachment areas.

Fig. 371

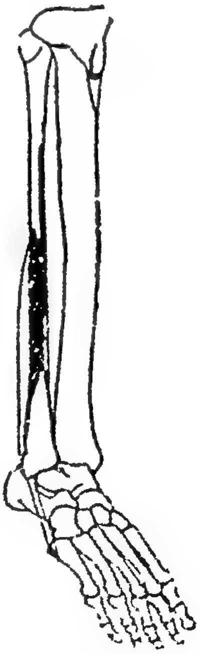


Fig. 372

Figs. 371 and 372.—The direct abductors of the foot.
Fig. 371.—Peroneus longus of right side; outline and attachment areas.
Fig. 372.—Peroneus brevis of right side; outline and attachment areas.

Rupture of Plantaris Tendon —The most common calf lesion is the rupture of the plantaris tendon This tendon has the appearance of a shoelace

The mechanism of the injury determines the lesion

The symptoms are sudden severe pain and inability to bear weight on the heel When the accident occurs while playing golf, the patient relates that as he was about to swing, the intense pain made him think he was struck by a golf ball Examination reveals a sensitive spot at the point of tear Roentgenograms are negative

Treatment includes adhesive, bandage or plaster support, elevation of the leg, strapping, applications of cold, elastic stocking and a raised heel

THE ANKLE

Ankle Disturbances	
Etiological	
1 Congenital	5 Infectious
2 Mechanical	6 Circulatory
3 Traumatic	7 Neurogenic
4 Metabolic	8 Neoplastic

The ankle is a hinge joint made up of the lower ends of the tibia and fibula which articulate with the astragalus The accurate relationship between these three bones is important The capsule is reinforced on all sides by ligaments The most important are the internal and external laterals There are no muscles in close relationship to the ankle joint but there are many important tendons especially the tendo Achillis, the anterior and posterior tibials, the peroneals and the extensor tendons of the toes

The ankle joint is the link between the body and the foot Because the foot is an organ of stability, motion and locomotion, the ankle joint must function properly It is surprising how well an individual can get along with only a comparatively few degrees of motion This is illustrated very well by a man wearing a good artificial leg There is very little lateral motion at the true ankle joint

The important conditions occurring in the ankle joints are sprains, synovitis, non-suppurative and suppurative arthritis, tuberculosis, syphilis, osteomyelitis, bursitis, fractures, dislocations, paralyses, tumors and epiphyseal changes The deformities at the ankle joint are called varus, valgus, equinus, calcaneus, and their combinations

Disturbances of the ankle include chiefly injuries, infections and static disturbances (One should review Chapter II for the mechanics of the region) A plumb-line dropped from the middle of the patella should follow the crest of the tibia and bisect the articulating surface

of the tibia, and the astragalus. The tendo Achillis should be parallel with the plumb-line dropped from the middle of the popliteal space.

The chief traumatic conditions found in the region of the ankle joint are: Fractures, dislocations, sprains and strains, stretching, rupture and tear of the ligaments and capsule of the joint. (Pott's fracture is discussed on page 314. Fractures in the region of the ankle joint are described on page 312. Dislocations of the ankle joint are discussed on page 352)

The chief infectious conditions in the ankle joint are suppurative and non-suppurative arthritis and tendon sheath infections.

The symptoms of disturbances of the ankle joint region are pain, swelling, limp and limitation of movement. The differential diagnoses may be divided into congenital, traumatic, infectious and miscellaneous conditions.

The prognosis in ankle joint conditions is very often unfavorable because it is a joint that involves not only stability but locomotion and one is often disappointed in his prognosis; and conversely, often surprised at the rapidity of improvement.

The treatment consists in non-operative and operative measures. Under the non-operative measures are rest, local applications, physical therapy, immobilization including adhesive strapping, plaster casts or braces. The operative measures are aspiration, arthrotomy, arthrodesis and arthroplasty.

The temporary treatment of an ankle sprain consists of immediate rest of the limb with elevation on a surface a little higher than the body and the application of cold cloths or ice bags immediately. The cold keeps the inflammation, irritation, hemorrhage and swelling down to a minimum. At a later time, heat is more beneficial in reducing pain. A snug, well-fitting bandage applied immediately will reduce the swelling and thereby minimize the amount of stretching of the supporting ligaments around the ankle joint. As soon as possible, a properly applied adhesive strapping will give considerable support, reduce pain and discomfort, reduce swelling and hasten recovery. After seven to ten days it should be removed and an elastic anklet substituted. Then gentle massage, light exercises and warm and cold foot baths are helpful. A high lace shoe, a pair of crutches or a cane are recommended.

Aspiration.—David concluded from experiments on 13 ankle joints of cadavers that the posterior external approach was a reliable and safe one so far as avoiding important structures is concerned. The joint cavity is easily accessible by this route and with the foot dorsiflexed to a right angle the evacuation of the fluid may be complete.

Osteochondritis Dissecans.—Osteochondritis dissecans occurs in the ankle joint—15 cases have been recorded. It may develop at any age. It is due to external trauma and may occur from minor injuries. The treatment is operative.

CHAPTER XXXV

SURGICAL TECHNIC AS APPLIED TO THE FOOT AND ANKLE

PREPARATION OF THE PATIENT

OPERATIONS on the foot and ankle require the strictest pre-operative preparation The most important sources of infection are the patient's skin, the skin of the operator and his assistants and nurses, faulty preparation of the nurse, faulty sterilization of instruments and sutures, traumatization of the tissues, prolonged surgery and loss of blood

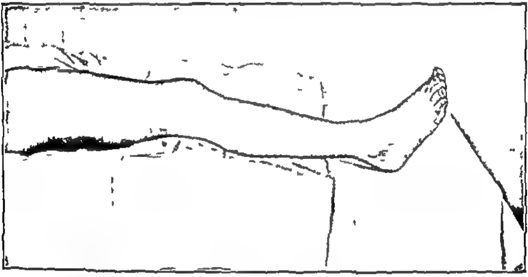


FIG 373 —Draping of foot and ankle Skin prepared from toes to just below knee Foundation sheets and towel in place (Campbell Operative Orthopedics courtesy of The C V Mosby Company)

Whenever possible, operative preparation should cover a period of two days On successive days the preparation is as follows

First day Bath and shaving Removal of grease or oil with benzine, application of $3\frac{1}{2}$ per cent iodine followed by alcohol and dry sterile dressings securely held in position Iodine burns must be guarded against especially under the edges of towels and sheets and particularly in the cases of patients with fair complexions Iodine should be followed by alcohol In some clinics mercurial preparations are used

Second day Application of alcohol and dry sterile dressings

Every patient entering the operating room should have some form of perineal shield

No matter how many maneuvers are used in the immediate pre-operative preparation, one should apply the sponge (on a sponge holder) to the operative site first and gradually work away from it in an ever-increasing circle and never return with the same swab.

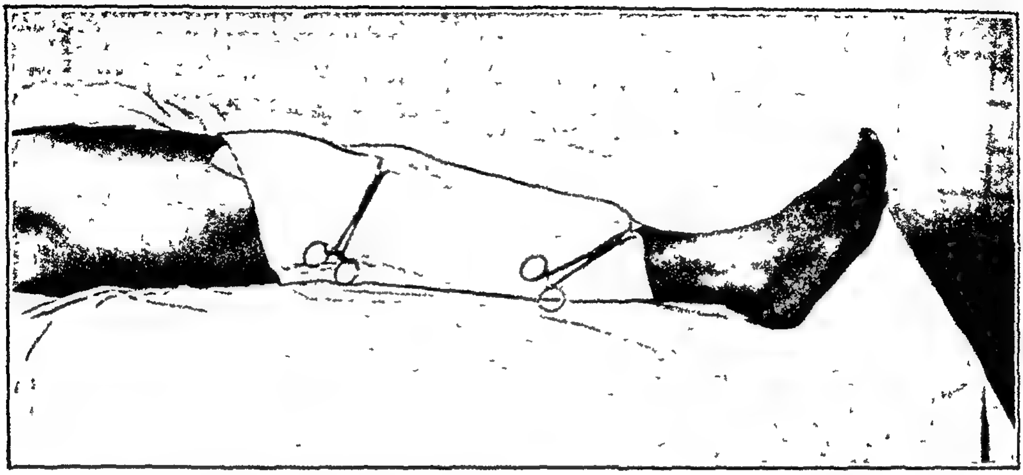


FIG. 374.—Leg enveloped in sterile towel. Towel clips should not puncture the skin. (Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

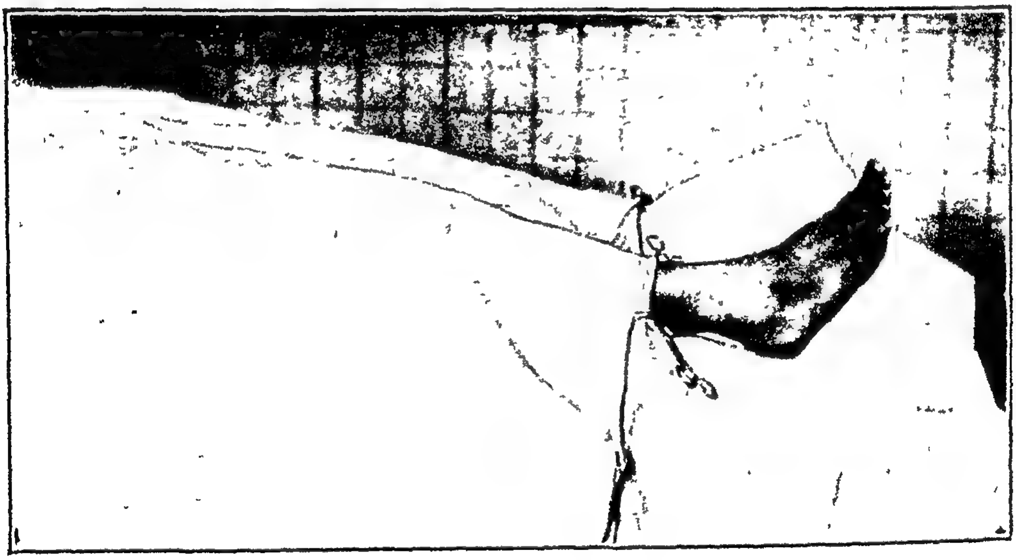


FIG. 375.—Top sheet fastened to draw sheet by towel clips. (Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

Hoke's pre-operative procedure for foot operations includes: (1) bath; (2) preparation of the leg from the toes to the groin; (3) shaving of the leg; (4) pedicure of the toenails; (5) thorough washing with green soap and water; (6) painting of the leg with a solution of potassium permanganate; (7) washing with alcohol; and (8) wrapping of the entire

leg and foot in sterile towels and secure bandaging Procedures from 5 to 8 are done with sterile gloves In the operating room, after the

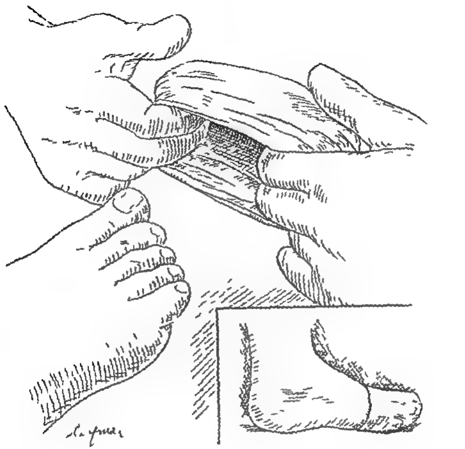


Fig 376 —Rubber toe guard used in all operations outside the toe area to isolate the toes

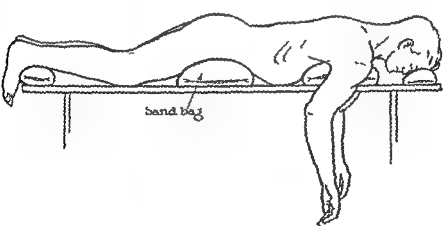


Fig 377 —Position of patient on table in preparation for plastic operations on Achilles tendon area

patient is asleep, the dressings are removed and the entire field is painted with a 30 per cent solution of iodine followed by alcohol

Draping of the Patient.—The isolation of the operative region is very important. In operations about the ankle, the toes can be excluded by a rubber glove or rubber toe guard (Fig. 376), or a piece of stockinet folded back and secured with a wide rubber band. The free use of towel clips is imperative. I have found bicycle pants-guards helpful in retaining linen around the arms and legs.

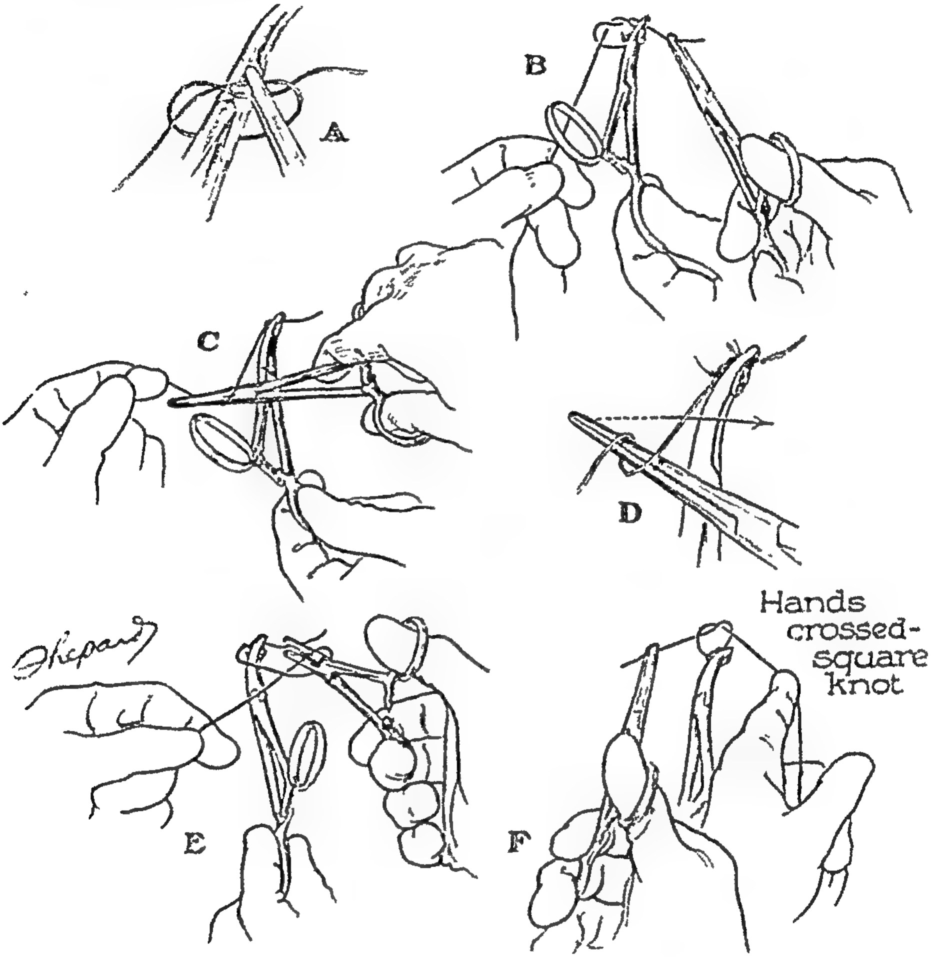


Fig. 378.—Tying surgical knots. No hand touch technic (Murphy). (By permission of Johnson & Johnson.)

Tourniquets—Constrictors.—Tourniquets are very important in such operative procedures as subastragalar arthrodesis, débridement, tendon transplantation and hallux valgus correction.

The usual locations of application of tourniquets are: mid-thigh, garter-line and above ankle.

The types of tourniquets are: Esmarch's band, Martin's bandage, Campbell's pneumatic and Conn's pneumatic.

The dangers of constrictors are compression of tissues causing trauma, injury to blood-vessels predisposing to thrombosis and embolism and injury to peripheral nerves causing paralysis.

Constrictors are used in operating on the lower limb to render the field of operation bloodless This is important in operations on tendons, nerves, bones and joints In arthroplasties and in operations for osteomyelitis it is important for the field to be bloodless Constrictors minimize the danger of infection because when they are used, the frequent application of sponges which favors infection, is unnecessary

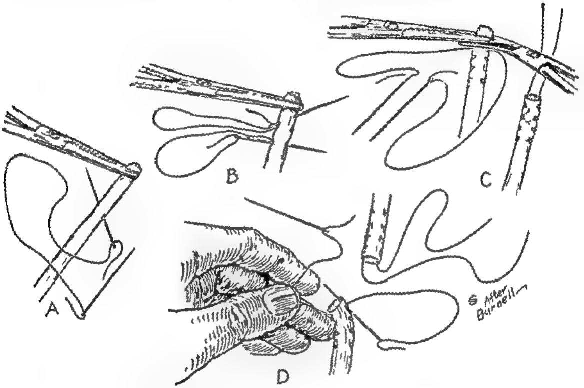


FIG 379 —Bunnell method of tendon suture (Redrawn from Bunnell Jour Bone and Joint Surg Campbell Operative Orthopedics courtesy of The C V Mosby Company)

The main types of constrictors are the Martin bandage, which is a pure rubber elastic bandage, the Esmarch constrictor which is a flat piece of rubber about 1 inch wide and $\frac{1}{8}$ inch thick, with a metal hook at one end and a chain at the other and Campbell's pneumatic apparatus Constrictors should always be applied over a towel The use of an expulsion bandage before the constrictor is applied is advised An excellent method of rendering a limb bloodless consists in applying a Martin bandage with each layer covering one edge of the preceding layer and going from the tips of the toes more than half way up the thigh When the limb is rendered bloodless by this method, an Esmarch, Campbell, or Conn constrictor is applied over a towel at the upper end Then the turns of the Martin bandage are removed When a constrictor is removed from a limb at the close of an operation, the limb should be gently massaged in order to allow the blood-vessels

whose walls have been compressed and agglutinated to become patent. Constrictors should be removed as soon as feasible. Whenever possible, they should be removed within an hour.

Severe damage of peripheral nerves can occur as a result of the application of a rubber tourniquet for surgical ischemia.

Factors involved in the production of the paralysis are (*a*) excessive pressure at the site of tourniquet application, with fibrosis and production of neuromas, (*b*) ischemia below the site of application of the tourniquet with death of the ischemic portion of the nerve, fibrosis and production of a neuroma in continuity, and (*c*) a combination of the foregoing two situations.

The radial and sciatic nerves are the most vulnerable to tourniquet paralysis.

Every case of tourniquet paralysis of a peripheral nerve immediately on its discovery should receive intensive physical therapy over a period of eight to twelve weeks. If, at the end of this time, no appreciable return of function is evident, surgical exploration of the involved nerve should be performed and a neurolysis or even neurorrhaphy (if feasible) should be attempted.

The Campbell-Boyd pneumatic constrictor appears to be the most efficient and least harmful of the constrictors.

The majority of cases of paralysis of a peripheral nerve following the use of a rubber tourniquet for surgical hemostasis show only an evanescent paralysis with involvement lasting a few days or weeks, followed by complete remission of symptoms. Montes, in 1888 described permanent peripheral nerve paralysis as a result of the use of a tourniquet. Putnam in 1888 described complete paralysis of nerves following the application of a rubber tourniquet during a surgical procedure. The patient had a reaction of degeneration in the involved muscles.

Eckhoff, described 14 cases of tourniquet paralysis with varying degrees of permanence and severity. Ten of his cases were cured in three months, 3 cases were cured in five months and 1 case improved in six months. All received intensive physical therapy. An interesting observation in some of his cases was the return of voluntary power before the return of faradic current response. In general, recovery takes place in from one to six months.

Burman in 1940 was the first to report a case of tourniquet paralysis in which the involved nerve (sciatic) was explored surgically. Exploration at the level of the tourniquet revealed that the "medial portion of the sciatic nerve was flattened and compressed for a distance of 1 inch, and the lateral nerve was covered by a small organizing fibrinous hemorrhagic exudate." Neurolysis was performed, and in nine months complete recovery had taken place.

Few cases of permanent paralysis secondary to the use of a tourniquet have been reported in the literature. Of the 18 cases noted in the literature, 16 were not permanent, the majority being less than three months, and 2 cases were presumably permanent. Speigel had under his care during eighteen months, 970 peripheral nerve injuries, almost all of which were battle casualties. Among this group there were 3 cases of permanent paralyses secondary to the use of the tourniquet.

Allen, concluded that one of the main causes of death of a nerve following the use of a tourniquet is necrosis of nerve fibers from direct pressure at the tourniquet site. Another important factor, according to Allen, is local asphyxia, and experiments to bear this out are mentioned. In these experiments the factor of local tourniquet pressure was excluded and organic destruction of the nerve fiber still took place after from one to several hours following ligation of the main vessels of the limb. According to him, narrow rubber bands or tubes are less harmful and painful than broad tourniquets. His reasons are logical—a wide tourniquet at the same pressure as a narrow tourniquet is pressing on more surface than the narrow tourniquet and therefore can do more harm. In actual practice, however, Lewin noted that it is less harmful to use a broad tourniquet, the explanation being that a force applied over a greater surface is less harmful than an equal force applied over a smaller surface.

Denny-Brown and Brenner believe that the effect of pressure on a nerve is entirely an ischemic phenomenon. The effect of pressure on conduction is graded by these authors as follows:

1. Nil
2. Paralysis with rapid complete recovery on release of pressure
3. Paralysis with delayed recovery without degeneration
4. Complete anatomic lesion with degeneration

In their experiments on the effect of pressure on conduction in peripheral nerves, Bentley and Schlapp postulate a critical value of 130 mm. of mercury applied over a period of two to three hours for the production of nerve block. They state also that the time taken for the establishment of nerve block by direct pressure is much longer than that observed in ischemia. These authors stress the fact that pressure block has different characteristics from block due to ischemia and that the time taken for the establishment of nerve block by direct pressure is much longer than that observed in ischemia. The exact nature of the pathologic involvement is not known. There is no question, however, about the presence of intraneural scar and neuromas in all the cases by palpation of the lesion as determined by palpation. The only apparent causes for this involvement would therefore appear to be either pressure necrosis at the site of tourniquet application with fibrosis and neuroma formation or ischemia below the site of applica-

tion of the tourniquet, death of the ischemic portion of the nerve, fibrosis and neuroma formation. Whatever the cause, however, the end result in all 3 cases was fibrosis and neuroma formation.

The sciatic nerve while less vulnerable than the radial to compression between the bone and the tourniquet, is still not immune, since there is no great abundance of muscle present to act as a cushion between it and the femur.

The femoral nerve, by virtue of more superficial positions and the heavy muscular pads between it and bone (at the usual tourniquet sites), is less frequently involved.

A bloodless field is vital in certain surgical procedures on tendons, bones and joints. It aids materially in accomplishing precision technic with the greatest speed, minimal loss of blood and minimal danger of infection, besides substantially reducing the possibility of fat embolism in operations on the long bones.

The main type of constrictors are:

1. The Martin bandage, a pure para elastic rubber bandage obtainable in sizes ranging from 2½ inches by 9 feet to 3 inches by 12 feet.
2. The Esmarch band, a flat piece of heavy rubber about 1 inch wide and ⅛ inch thick, with a metal chain at one end and a metal hook at the other.
3. The Campbell-Boyd and Conn pneumatic apparatus.
4. Rubber tubing and a clamp.

It is recommended that any type of constrictor other than the Campbell-Boyd type be applied over a towel. The limb should be rendered bloodless by first elevating it for two minutes. A Martin bandage is then applied with each layer covering one edge of the preceding layer, extending from the tips of the toes more than half way up the thigh. Following this procedure, the constrictor is applied. The constrictor should be removed within an hour if feasible. In longer operations it is advisable to release the constrictor for a few moments and then renew the constricting force. Following the final removal of the tourniquet, the limb should be gently massaged in order that the blood-vessels whose walls have been compressed may resume their patency. The use of the Campbell-Boyd pneumatic constrictor is attended with the least danger to vessels and nerves. It can be inflated and deflated without danger to sterile drapes and it allows for an even pressure exactly determined and distributed over a large area.

Campbell-Boyd Pneumatic T[illegible] The tube is i[illegible] complete soft leather cloth casin[illegible]

The amount of pressure requi[illegible] 'pon the si[illegible] dividual extremity. For an av[illegible] ult, twel[illegible] pressure [illegible] the thigh and eigh[illegible] essure f[illegible]

extremity are the maximum The pressure for children is proportionately lower

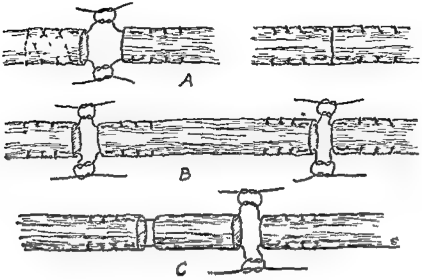


FIG 380 —Bunnell method of tendon splicing (Redrawn from Bunnell Jour Bone and Joint Surg Campbell Operative Orthopedics courtesy of The C V Mosby Company)

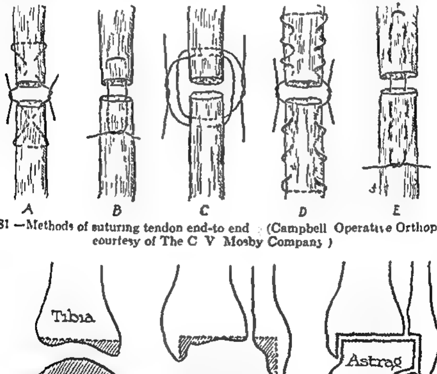


FIG 381 —Methods of suturing tendon end-to-end (Campbell Operative Orthopedics courtesy of The C V Mosby Company)

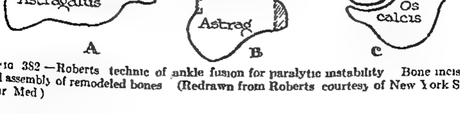


FIG 382 —Roberts technic of ankle fusion for paralytic instability Bone incisions and assembly of remodeled bones (Redrawn from Roberts courtesy of New York State Jour Med)

A pneumatic tourniquet should not be used unless the exact amount of pressure can be measured. For testing the pressure, one can employe a gauge through which the air passes and it can be read at all times. There is no loss of pressure at any time. Deflation may be made with a deflation screw at will.

This pneumatic tourniquet has the following advantages:

1. Pressure is applied evenly over a large area, and the exact amount of pressure is known. This may be the means of preventing tourniquet paralysis.

2. It is easily applied and may be deflated at any time without disturbing the operator or the sterile surgical drapes. This often saves valuable time during the course of an operation.

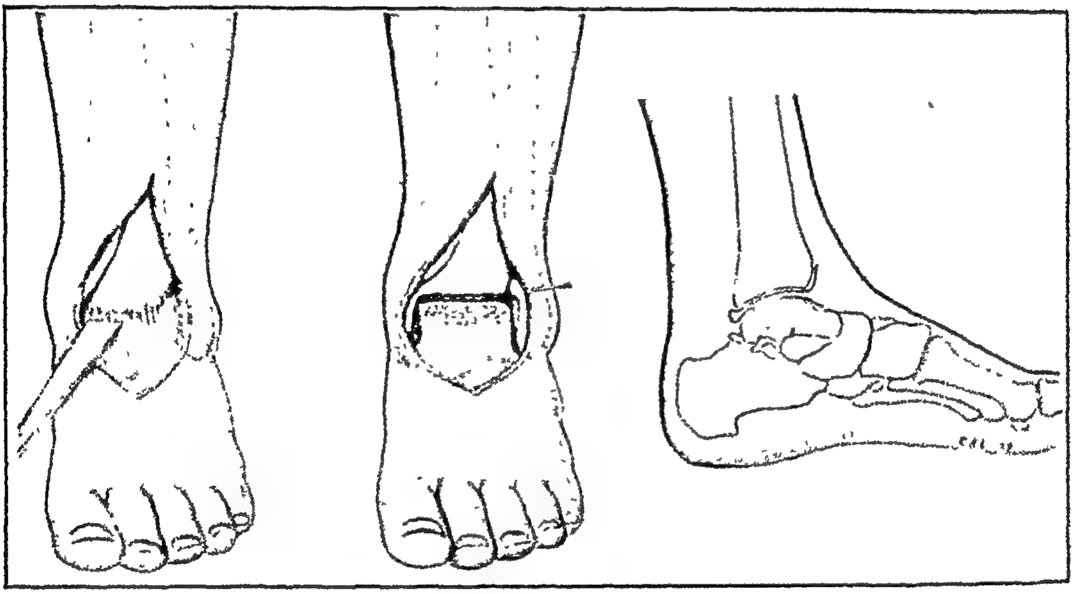


Fig. 383.—Arthroplasty of the ankle. *From left to right:* exposure of joint; remodeled articular surfaces; interposition of fascia latæ to form a double lining. (Campbell: Operative Orthopedics, courtesy of The C. V. Mosby Company.)

Operative Technic.—There is no type of surgery in which the Lane technic should be used more scrupulously than in bone and joint operations on the foot and ankle. Such operations should be performed under the strictest aseptic technic. No fingers should be allowed to touch the wound or the skin. Only the "working" ends of the instruments should come into contact with the wound, and any instruments that touch the skin should not be allowed to touch the inside of the wound. All knots must be tied with forceps—not by hand.

Removal of Sutures.—The surgeon must be meticulously careful in suturing all incisional wounds but must be especially careful in suturing incisions in the plantar surface. I recommend deep and superficial

tension sutures to control hemorrhage and minimize scar tissue It is important also to leave the sutures in place two or three extra days to prevent gaping of the wound and the formation of excessive scar tissue

OPERATIONS ON THE FOOT AND ANKLE

The chief operations performed on the foot and ankle are arthrodesis of the subastragalar and neighboring joints, operations for bunion, bunionette, and hallux valgus, hammertoe correction, the removal of calcaneal spurs, tendon transplantation, osteotomy, and amputations Indications for operations are deformity, disability and infection

The Seven Wonders of Surgery

1 Asepsis
2 Anesthesia
3 Precision diagnosis
4 Roentgenology
5 Surgery
6 Transfusion
7 Chemotherapy penicillin, sulfas, sulfamylon, streptomycin, heparin

Remarks None of them is worth anything unless the doctor possesses good judgment

The Greatest Discoveries of Surgery

1 Anesthesia
2 Asepsis
3 Roentgenology
4 Chemotherapy

The Surgeon Should Teach the Nurse

1 The cardinal signs and symptoms of shock
2 The local criteria of disturbed circulation
3 The diagnosis of the patient's illness
4 Approximately what was done in the operating room
5 The most frequent complications in similar cases
6 The danger signals which indicate the development of complications
7 To report accurately and concisely
8 The mechanics of any apparatus being used, and report any derangement
9 The basic pharmacology of important drugs
10 Drug idiosyncrasies and their manifestations
11 Not to overlook or ignore a patient's complaints, but to report them

Operating Room Technic.—Leggings are desirable for all male personnel in the operating room. I like bicycle pants guards in addition. A good shoe covering can be made by tying the end of a strip of stockinette.

Mouth gauze must cover the nose.

Fogging of eye glasses can be avoided by rubbing a little soap on the glasses and polishing thoroughly. There is a commercial product called De-Ge which is very satisfactory.

Every long orthopedic operation calls for a preliminary transfusion of 500 cc. of plasma or blood.

While Chief of the Orthopedic Section at Mayo General Hospital, I outlined the following routine preparation of the skin for operation upon bones and joints:

FORTY-EIGHT HOURS BEFORE OPERATION

Medical Preparation:

1. Removal of skin scales and crusts.
2. Removal of any adhesive spots on the skin by gentle use of ether, carbon tetrachloride, or similar material.
3. Gentle cleansing of the skin using mild soap with water.
4. Shaving the skin but no irritation, scraping, or nicking.
5. Washing the soap off and drying the skin.

Chemical Preparation:

6. Application of one coat of 3½ per cent tincture of iodine and allow to dry.
7. Removal of all iodine with 70 per cent alcohol.
8. Alcohol should be allowed to dry.

Dressing:

9. Application of sterile dressings.
10. Application of retention dressing—sleeve, trouser, bandage or stockinette.

Protection:

11. Dressing secured so that it will not be dislodged by the patient before the operation is performed.

TWENTY-FOUR HOURS BEFORE OPERATION

1. No shaving, no cleansing, no iodine.
2. Apply (*a*) alcohol, (*b*) dressing, (*c*) protection.
3. Skin is not to be irritated by vigorous rubbing, strong chemicals, or by stiff dressing.

General—Skin scales harbor bacteria Where there are scales or thick heavy scars, it is advisable to send the patient to Physical Therapy for whirlpool baths for several days prior to operation

The mercurial preparations are in great favor as a means of sterilizing skin before the incision is made

BLOOD AND BLOOD SUBSTITUTES

The concept of blood transfusion therapy has undergone a radical change in the last decade The various constituents of blood, that is, the cells and the various fractions of the plasma proteins, have different properties and different functions The decision, therefore in employing hemotherapy for a patient is based upon a consideration of the needs of the patient When blood transfusion is being considered, the question is asked, "*What fraction of the blood has the patient lost?*" The therapy that is employed is based upon the answer to that question

The reason for this approach to hemotherapy is due to the progress made during the war in separating the blood into its two essential components—the cells (principally erythrocytes) and the plasma Furthermore, the work of Edwin Cohen in fractionating the various component parts of plasma has added much to the progress of selective therapy

It is obvious that in acute hemorrhage all the fractions of the blood *are lost and, therefore, the correct therapy is replacement with whole* blood Plasma may serve as an interim therapy to maintain circulating blood volume and to combat shock until the laboratory work of preparing compatible blood is completed In shock and in burns the essential loss is plasma Therefore, the best therapy is plasma restitution On the other hand, in slowly developing anemias in which there is no hypoproteinemia the patient requires red cells In conditions such as these, red blood cell transfusions prove to be as effective, and possibly more effective, than whole blood transfusions In conditions characterized by hypoproteinemia, *plasma will serve to restore the* plasma proteins If there is an accompanying anemia, whole blood is indicated

A cardinal consideration in the use of whole blood or any of its fractions is the amount to be administered The amount used should always be sufficient to correct the condition which is being treated Since the clinical picture varies so markedly from patient to patient, the dose of blood cells, plasma, or fractions of plasma must be determined by the deficiency in the individual patient, and this deficiency should be restored *in toto*

Another important consideration in the use of blood or any of its fractions is the rate of administration of these substances If the con-

dition of the patient is one in which there is oligemia due to rapid loss of blood or plasma, the transfusion should be as rapid as possible in order to restore the original circulating blood volume. Prolonged oligemia is accompanied by tissue anoxia and may result in shock. This oligemia, therefore, must be corrected as rapidly as possible. On the other hand, if the blood volume is normal and hemotherapy is employed for one or another reason, the blood or fractions of blood should be administered just as rapidly as the body can accommodate the infusion of the material without strain on the cardiovascular system. Too rapid transfusion of blood or blood fractions can result in overburdening the right side of the heart and in pulmonary congestion and edema. This may lead to subsequent pneumonia. It can be avoided by the slow infusion of blood or its fractions.

Blood or red blood cells must always be used with due consideration to careful blood grouping, including the Rh character of the patient and the donor blood. Furthermore, every precaution in the use of material and solutions should be employed to prevent the occurrence of unfavorable reactions.

CONCENTRIC ARTHRODESIS OF THE ANKLE JOINT

Indications.—Operations for fusion of the ankle joint are indicated for serious infections, flail joints, and especially traumatic arthritis. The joint sequelæ of ankle fractures are frequently caused by incomplete reduction, but persistent ankle symptoms occasionally follow a perfectly reduced fracture.

The disabling symptoms of traumatic arthritis can be eradicated by successful fusion. Anderson believes that present-day procedures for arthrodesis leave much to be desired. An important cause of poor results is unsatisfactory immobilization. A circular cast, even though it extends to the upper thigh, will not absolutely immobilize the ankle in an ambulatory patient.

Anderson's Concentric Arthrodesis Using Transmallcolar Approach.—By the transmalleolar approach, the ankle joint can be easily resected, and the pitfalls of accepted methods may be avoided. The basis of this method is a bilateral approach to the ankle joint by subperiosteal resection of the malleoli. Once the malleoli have been removed, the entire tibiotalar articulation is accessible to the surgeon. Incomplete contact resulting from impingement of the malleolar tips is eliminated by resection of these structures.

The second step in the procedure consists in resection of cartilage and subchondral dense bone in such a manner that the resulting cancellous bone surfaces are concentric. Such resection can be conveniently effected by means of a special curved osteotome.

The transmalleolar approach to the ankle joint, with excision of the malleoli, provides surgical access to the entire joint under direct vision

Resection of the joint with an osteotome, the curve of which conforms to the arc of the ankle joint, assures an exact osseous approximation, regardless of the degree of equinus

Subperiosteal resection of the malleoli permits direct contact between the talus and the tibia

Resection of the malleoli and the rounding of their bases make a narrow and shapely ankle

Bilateral incisions supply a means of obtaining simultaneously drainage of the joint and fusion in septic compound fractures, even in the active stage of infection

Immobilization by means of transfixion pins (or Kirschner wires) fixed by either the cast or castless methods, is so positive and complete that early crutch ambulation can be permitted with safety

TECHNIC OF FUSION OF THE ANKLE

Boyd describes ankle fusion of two general types anterior and posterior The posterior method, which was developed as a partial extra-articular procedure for the treatment of tuberculosis of the ankle, is suitable for malunited fractures wherein arthritic changes are present in both the ankle and subtalar joints Following this operation, however, patients have more difficulty in walking over rough ground If the subtalar joint is normal, its motion should be preserved by the use of the anterior method of fusion

Anterior arthrodesis is the operation of choice in the majority of malunited fractures of the ankle requiring fusion The ankle is exposed through an anterolateral incision The articular cartilage is removed from the superior lateral and medial surfaces of the talus and the corresponding areas of the ankle mortice A slot is cut in the neck of the talus and a bone graft from the anterior surface of the tibia slid down into this prepared bed, thus bridging the joint Or, if desired, a free graft from the upper portion of the anteromedial aspect of the tibia may be used to bridge the joint The latter method gives a more stable graft but requires a more extensive operation Good fusions have been obtained by both procedures The wound is closed and a cast applied from groin to toes with the knee at 150 degrees extension The long leg cast is preferable for maintaining the relation of the foot to the ankle

THE REPAIR OF SURFACE DEFECTS OF THE FOOT

The skin and subcutaneous tissues of the sole of the foot constitute a specialized organ Similar structure does not occur elsewhere in the

body. Covering, transplanted to the sole from other areas of the body, does not become a normal sole. There may be difficulty in maintaining a satisfactory condition of tissues transplanted to the sole. Keratosis, warts and cracks may require frequent attention, and chronic ulcers may occur. Only substitutions can be made for losses of the sole.

The commonest causes of trouble are shell fragment and gun-shot wounds, burns, traffic accidents, warts, decubitus, radiation, and cold injuries.

Preoperative care is necessary for any type of operation, and includes rest, baths, soap and water, sulfonamides or penicillin, fine-mesh gauze next to open wounds, cotton mechanics waste, or latex-foam pressure dressings, and elastic bandaging of the foot and leg. Bacterial studies are made on chronic ulcers and every effort is made to get them as clean as possible. No repair or operations should be attempted until all sloughs, dead tendons, fascia and bone are disposed of, and there is a good tendency to healing and the development of a minute blood supply that will support the transplanted tissue. Physical therapy procedures are very helpful. Inflammation and edema of the foot or leg are contraindications. Flaps require the closest attention to detail because loss of one is more serious than loss of a free graft. Patients with lost flaps are worse off than originally.

Direct cross leg flaps from the opposite thigh or calf can be used for many defects, if a suitable position can be decided on, and the patient is capable of accepting the distorted life for the necessary period of healing.

A soldier cannot go back on full duty soon after a large foot repair. To do so usually means further trouble after the first hike. Dried sebum and crust formation also may lead to ulceration. The frequent use of massage and cold cream or lanolin will help keep the area soft. Where the thin soft repair joins the hard keratotic normal sole, there may be excessive keratosis and even annoying wart formation of the repair. Prevention is much better than cure. Careful cleansing, attention and nursing are required.

The failure of grafts and distant flaps have led some suregons to the opinion that only sole tissue should be used on the sole—even if a cross sole flap has to be used; but the difficulty is not as great as this concept. Certainly, in a large series of repairs there [14] be much more total failure from cross sole fl ... ones, although it is recognized that the ... in occasional instances

Results of repairs of the foot ... Dramatic relief from painful ... flaps or even grafts. The esse... repair the defect and get healing

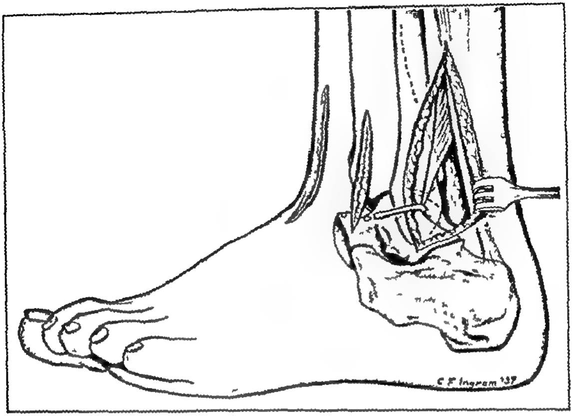


FIG 384 —Posterolateral anterolateral and anteromedian incisions for drainage of ankle (Campbell Operative Orthopedics courtesy of The C V Mosby Company)

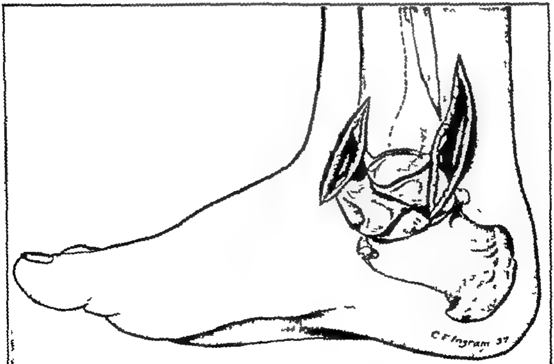


FIG 385 —Posteromedial and anteromedial incisions for drainage of ankle (Campbell Operative Orthopedics courtesy of The C V Mosby Company)

in every way to protect the repair from trauma. The foot and its sole is an area of the body that can only be substituted for, once it is lost.

Anesthesia may be local or general. The local anesthetic is novocain.

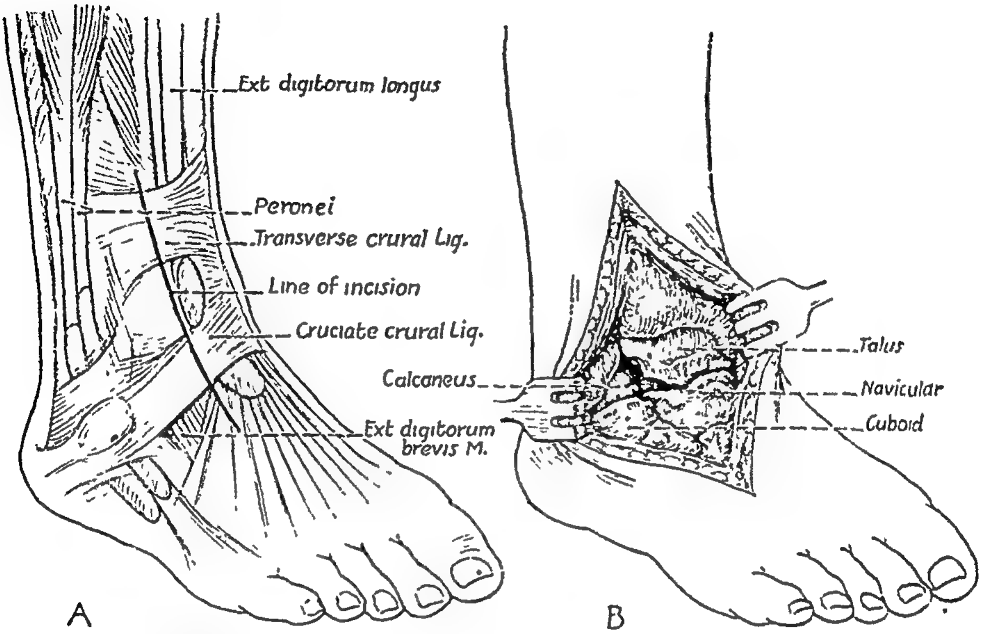


FIG. 386.—Anterolateral incision for exposure of ankle joint and tarsus. (Campbell, Operative Orthopedics, courtesy of The C V Mosby Company.)

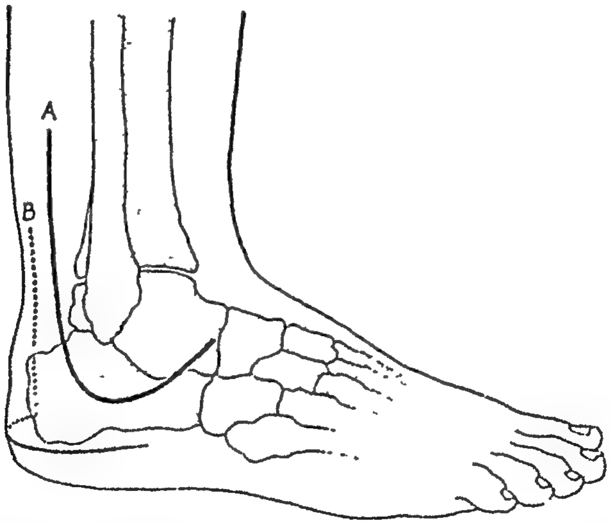


FIG. 387.—*A*, Kocher approach to ankle. *B*, Kocher approach to os calcis. (Campbell, Operative Orthopedics, courtesy of The C. V. Mosby Company.)

General anesthesia is usually induced with gas, cyclopropane, pentothal sodium or ether. Tourniquets are of great value in operations on the foot and ankle. The toes should be excluded by rubber gloves, rubber

socks, or rubber toe guards. Pants-guards or bicycle-guards are used on the drapes above the ankle. Operations are performed on the bones, joints, tendons, nerves, blood-vessels, skin, and muscles. Tenotomies or tendon lengthenings are done more frequently in the foot than any-

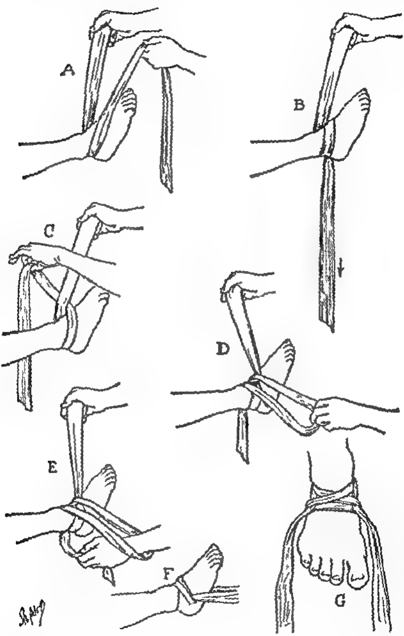


FIG. 388.—Diagram of Collins hitch for use in applying traction. (Magnuson: Fractures; courtesy of J. B. Lippincott Company.)

where else in the body. Operations on the peroneal tendons are transplantations and tenodeses. Operations done on the Achilles tendon are chiefly for lengthening, shortening, or repair. Osteotomies are performed on the bones of the foot and ankle.

The position of the patient on the table should be such as will permit the most expeditious approach to the operative field. For operations on the Achilles tendon, the patient should be on his face with a sandbag under the dorsum of the foot. Sandbags are very helpful in operations

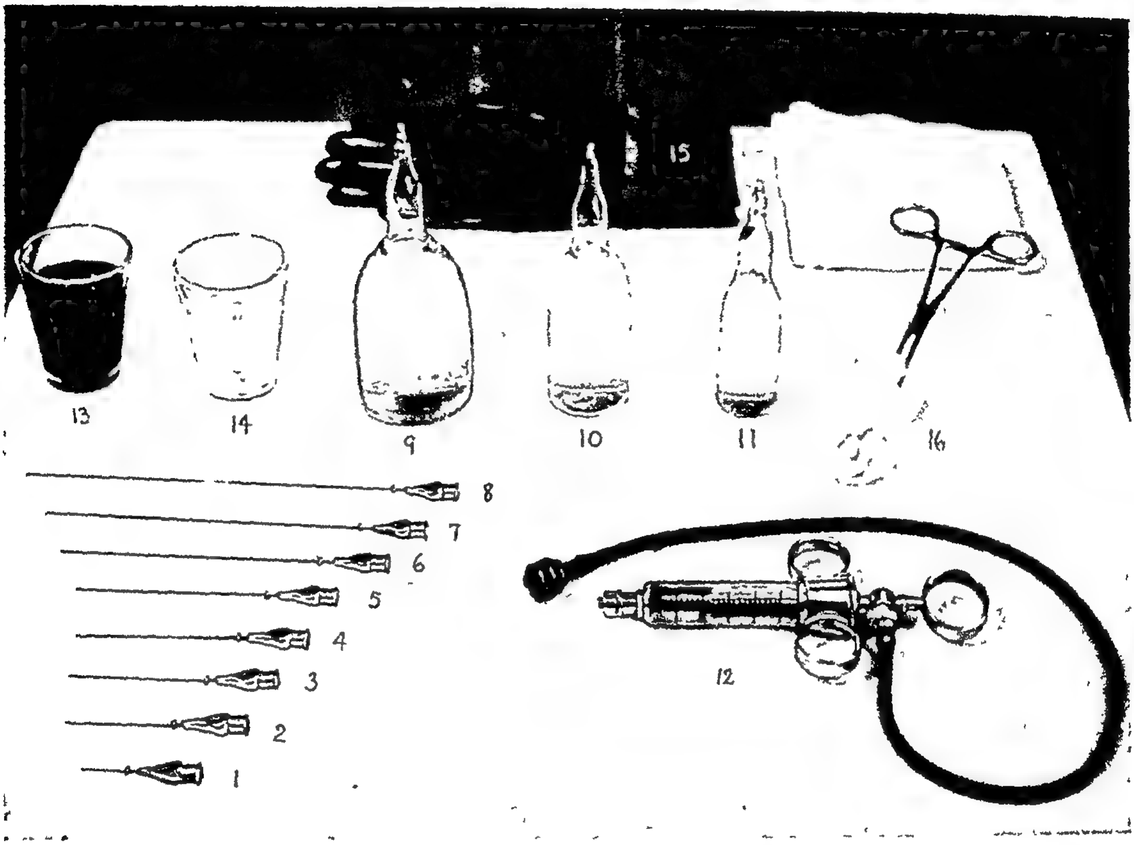


Fig. 389.—Table set up with essentials for conduction anesthesia *1*, needle $\frac{3}{4}$ inch 25 gauge; *2*, $1\frac{1}{2}$ inch 22 gauge; *3*, needle 2 inch 22 gauge; *4*, needle $2\frac{1}{2}$ inch 22 gauge; *5*, needle 3 inch 22 gauge; *6*, needle 4 inch 22 gauge; *7*, needle 5 inch 22 gauge; *8*, needle 6 inch 22 gauge, *9*, *10* and *11*, 100 cc., 50 cc., and 25 cc. ampules of novocain solution, *12*, Pitkin continuous flow syringe; *13*, iodine solution; *14*, alcohol; *15*, gloves, *16*, gauge and sponge holder (Pitkin, courtesy of Am Jour. Surg.)

on the foot and ankle. Following most operations, casts or bandages are used. Sideman's "windmill" is valuable as an elevator. The heat cradle and the wire cradle are useful.

Skin incisions should be made with careful thought to avoiding the more important weight-bearing and pressure points of the foot. Painful scars beneath the great toe joint or under the calcis are to be avoided if possible.

LOCAL ANESTHESIA

The branches of the sciatic nerve may be blocked separately. The external popliteal may be blocked with ease.

Complete anesthesia of the lower extremity demands the blocking of the sciatic, external femoral cutaneous, femoral and obturator. The femoral artery can be identified directly below Poupart's ligaments. A skin wheal is raised just external to the course of the artery. Through this, the needle is introduced vertically. Making slight pressure with the index finger of one hand, the artery is forced mesially while the needle pierces the fascia. Anesthesia may be produced by injecting about 20 cc. of 2 per cent novocain-adrenalin solution beneath the fascia and into the muscle.

Toes.—Any digit may be blocked by infiltration at its base. The larger nerves travel on the lateral aspects. No special effort should be made to reach individual branches, an infiltration block completely saturating the tissues is all that is required. For each digit two skin wheals are necessary, one upon each side on the dorsolateral surface. The second wheal should be made by the subdermal method. If more than one digit is to be anesthetized, the needle should be carried subdermally from the base of one digit to the next and so on.

When infiltrating the foot or toes, the infiltration should begin on the dorsal surface. One should introduce the needle through a wheal made upon the dorsal surface and carry it down to and past the bone beneath the palmar surface, injecting continuously as the needle advances. Where it is necessary to establish anesthesia of several digits the most satisfactory manner is to make an infiltration block at the ankle. Sixty cc. of 1 per cent novocain-adrenalin introduced just above the ankle-joint will give perfect anesthesia in about ten minutes.

It is unwise to attempt to introduce a hypodermic needle through the integument of the sole of the foot as an initial step. In the case of the digits, most authorities advise avoiding the use of adrenalin. However, Farr uses it in all cases in which the integrity of the blood supply is unimpaired. When not contraindicated the tourniquet may be employed.

Amputations.—Amputations, from the standpoint of anesthesia technic, fall into the same class as fractures and open operations upon the extremities. A fair percentage must be made in patients who are bad risks. In using local anesthesia in cases of amputation for vascular disease with an inadequate circulation, the adrenalin should be reduced to 1 minim per 30 cc. of the anesthetic solution. It is well to outline the flaps with a subdermal line of infiltration as a preliminary step to all major amputations.

Hallux Valgus and Bunions.—The operation for bunions is almost an ideal one for the use of local anesthesia. The anesthesia is easily established.

In bilateral operations, anesthesia should be established in both feet before the operation is begun. A skin wheal is made upon the dorsum of the foot over the base of the first metatarsal. From here a subdermal infiltration is made ventrally as far as the junction of the dorsum with the sole of the foot, at which point a secondary wheal is formed from beneath. Likewise, a subdermal infiltration is made dorsally in a transverse direction. Through these lines of infiltration all subcutaneous tissue is infiltrated. In addition a subdermal infiltration should be made vertically along the dorsum of the foot to a point between the first and second toes. Through this line the first and second metatarsals are isolated by a plane of infiltration. About 60 cc. of 1 per cent novocain-adrenalin solution are required for each operation.

No attempt is made to pass the needle through the unanesthetized skin of the plantar surface of the foot.

A Guide in Writing Up Operations

For surgeon, interne, resident. May be very important in court.

1. Position on table.
2. Local preparation.
3. Anesthesia.
4. Tourniquet.
5. Incision.
6. Isolation of skin edges.
7. Dissection.
8. Findings.
9. Procedure—technic.
10. Foreign material used.
11. Repair—suture materials.
    structures united.
    inspection of wound revealed no sponges, skin clips, etc.
12. Closure—material.
    technic.
13. Dressing.
14. Splinting or cast.
15. Condition of patient on leaving operating room.
16. Specific orders given to nurse.

APPENDIX

FOOTNOTES AND FOOTSTEPS—PEDIGRAMS

THE following comprise a series of what I have termed footnotes or pedigrams

The future of the race moves forward on the feet of little children— Phillips Brooks

One pair of feet must last a lifetime

Watch your step

Feet are among the first structures to show evidence of age, wear and tear, and stress and strain

Osler said "A man is as old as his arteries"

I say "A man may *be* as old as his *arteries* but he *acts* as old as his *feet* and *legs*"

Remember that no matter how long you live, you have to carry your feet and your feet have to carry you

While your feet are not vital organs they can vitally affect your health and vitality

When your ankles roll in, your foot troubles begin

Put your pride in your pocket and your feet in proper shoes

Get up on your toes or you'll be down on your heels

One shoemaker has a slogan "Put your feet in my hands"

Charm flies out the window when your feet hurt

Put your better foot forward, then make the other one just as good

Bad feet are good barometers of failing health

He who is no longer "up on his toes" will soon be "down on his uppers"

Take the arch out of your back and put it in your foot

Foot care is good foot insurance

Fatigue is a warning, pain is a danger signal, swelling may be serious

Minor foot conditions must be treated in a major way

It isn't the load that breaks us down, its the way we carry it

The height of your arch does not determine the strength or usefulness of your foot

A flat foot may give a good performance, whereas a high-arched foot may be incompetent

Flat feet are not necessarily painful feet

Flat feet plus "rheumatic" feet are very painful and stiff

Get your patient back to duty as soon as consistent with progress

Every extra day off duty because of immobilization, postpones by at least a week, the day when a patient will return to his duty

The "settling" foot is an indication of relaxation of the supporting structures.
The "bulging" foot is an indication of obesity or failing circulation.
Shoes are turned out by the thousands; feet are turned in pairs.
Shoes are perfect mates; feet are rarely perfect.
Overeating is usually reflected in the form of painful feet as well as pain in the abdomen.
Overeating may cause "foot dyspepsia."
Obesity throws additional strain on the feet.
It never hurt a patient with painful feet to be put on an anti-obesity, anti-gout diet for a few days.
In diagnosing foot complaints, always keep gout in mind.
Not all the gout in the world is in the big toe.
It is easy for a person to forget a minor injury.
There is no shoe too small for an ambitious female's foot.
Fit your feet and not the other person's eye.
Get a shoe that has the shape of your foot.
The study of foot disturbances has become an exact science and the treatment has become a fine art.
The most important shoe measurement is from the tip of the heel to the middle of the big toe joint which should come opposite that point of the shoe where the shank goes over into the sole.
It should not be necessary to "break in" shoes.
It is not necessary for most women to wear corrective shoes, but for all, the shoes must be correct.
Fit the sole of the shoe to the sole of your foot.
It is impossible to correctly fit many ladies' feet with low shoes.
Every woman's foot has three sizes; one while sitting, another while standing; and another, while walking.
The size of the foot changes during walking but the shoe does not.
Your feet may be larger after tramping around all day but your shoes are not.
If we had more correct shoes, we wouldn't need so many so-called "corrective" shoes.
Physician! *Know thy feet.*
With shoes the "last" shall be the first.
If the shoe fits wear it.
Cramping your feet will cramp your natural style.
A pair of high shoes is often as good as a crutch, and by the way, they relieve the knees of a great deal of strain.
In each of the 48 states of the Union, every blacksmith must have a state license to shoe a horse. In no state is a shoe-fitter required to have anything more than a yard stick, a shoe horn and a glib tongue. It doesn't sound like horse sense, does it?

A flexible shoe is sufficient for those who need only exercise, but for those who need both exercise and support, it is insufficient It may be used "part time" to alternate with a rigid shank shoe

Everyone should have one pair of shoes

A well-padded shoe insures a well-behaved foot

Many children go through childhood being continuously misfitted

The child walks on the same hard surfaces that adults do, namely hard floors, cement sidewalks and asphalt streets—therefore, he should have the same protection that adults have

Many children outgrow but never outwear their shoes

It is not necessary for most children to wear corrective shoes, but for all, the shoes must be correct

Observe your child's foot and leg posture occasionally, during sleep

Be on the lookout for improper sitting positions during rest or play

One of the worst sitting positions is that in which a child sits with its legs folded, so that the heels nearly touch its buttocks and its feet are in flat-foot position

Flat feet and a weak back are often found in the same child and adult

Keep your back flat and your feet arched

Teach your child to place his or her feet squarely on the ground, or squarely on the floor whether he or she is sitting, standing or walking

A slight degree of "pigeon-toes" may be desirable

The objects of modification of shoes are to give one support and to compel him to walk over the proper walking angle

The purposes of exercises are to strengthen the supporting structures of the arches and to stimulate the circulation

The aim of massage is to increase the circulation of the muscles of the feet in order that they may grow stronger by special exercises

The purpose of alternating hot and cold sprays is to furnish a tonic for the nerves, blood-vessels, muscles and ligaments

A heart-patient can get the foot exercise equivalent to two miles of walking in five minutes of massage, with no heart strain

There is no test that will write the name of the disease on the diagnostic score board

A movement a day keeps adhesions away (Coates)

It has been erroneously stated that "A sprain is worse than a break" Sprains are often neglected

Little bits of flat feet
Little squeaky knees
Make the Goldthwait sickness
Sacro-iliac disease

Be as exacting of your chiropodist, in cleanliness and sanitation, as you are with your manicurist, barber, waitress and physician

The "settling" foot is an indication of relaxation of the supporting structures.
The "bulging" foot is an indication of obesity or failing circulation.
Shoes are turned out by the thousands; feet are turned in pairs.
Shoes are perfect mates; feet are rarely perfect.
Overeating is usually reflected in the form of painful feet as well as pain in the abdomen.
Overeating may cause "foot dyspepsia."
Obesity throws additional strain on the feet.
It never hurt a patient with painful feet to be put on an anti-obesity, anti-gout diet for a few days.
In diagnosing foot complaints, always keep gout in mind.
Not all the gout in the world is in the big toe.
It is easy for a person to forget a minor injury.
There is no shoe too small for an ambitious female's foot.
Fit your feet and not the other person's eye.
Get a shoe that has the shape of your foot.
The study of foot disturbances has become an exact science and the treatment has become a fine art.
The most important shoe measurement is from the tip of the heel to the middle of the big toe joint which should come opposite that point of the shoe where the shank goes over into the sole.
It should not be necessary to "break in" shoes.
It is not necessary for most women to wear corrective shoes, but for all, the shoes must be correct.
Fit the sole of the shoe to the sole of your foot.
It is impossible to correctly fit many ladies' feet with low shoes.
Every woman's foot has three sizes; one while sitting, another while standing; and another, while walking.
The size of the foot changes during walking but the shoe does not.
Your feet may be larger after tramping around all day but your shoes are not.
If we had more correct shoes, we wouldn't need so many so-called "corrective" shoes.
Physician! *Know thy feet.*
With shoes the "last" shall be the first.
If the shoe fits wear it.
Cramping your feet will cramp your natural style.
A pair of high shoes is often as good as a crutch, and by the way, they relieve the knees of a great deal of strain.
In each of the 48 states of the Union, every blacksmith must have a state license to shoe a horse. In no state is a shoe-fitter required to have anything more than a yard stick, a shoe horn and a glib tongue. It doesn't sound like horse sense, does it?

A flexible shoe is sufficient for those who need only exercise, but for those who need both exercise and support, it is insufficient It may be used "part time" to alternate with a rigid shank shoe

Everyone should have one pair of shoes

A well-padded shoe insures a well-behaved foot

Many children go through childhood being continuously misfitted

The child walks on the same hard surfaces that adults do, namely hard floors, cement sidewalks and asphalt streets—therefore, he should have the same protection that adults have

Many children outgrow but never outwear their shoes

It is not necessary for most children to wear corrective shoes, but for all, the shoes must be correct

Observe your child's foot and leg posture occasionally, during sleep

Be on the lookout for improper sitting positions during rest or play

One of the worst sitting positions is that in which a child sits with its legs folded, so that the heels nearly touch its buttocks and its feet are in flat-foot position

Flat feet and a weak back are often found in the same child and adult

Keep your back flat and your feet arched

Teach your child to place his or her feet squarely on the ground, or squarely on the floor whether he or she is sitting, standing or walking

A slight degree of "pigeon-toes" may be desirable

The objects of modification of shoes are to give one support and to compel him to walk over the proper walking angle

The purposes of exercises are to strengthen the supporting structures of the arches and to stimulate the circulation

The aim of massage is to increase the circulation of the muscles of the feet in order that they may grow stronger by special exercises

The purpose of alternating hot and cold sprays is to furnish a tonic for the nerves, blood-vessels, muscles and ligaments

A heart-patient can get the foot exercise equivalent to two miles of walking in five minutes of massage, with no heart strain

There is no test that will write the name of the disease on the diagnostic score board

A movement a day keeps adhesions away (Coates)

It has been erroneously stated that "A sprain is worse than a break" Sprains are often neglected

Little bits of flat feet
Little squeaky knees
Make the Goldthwait sickness
Sacro-iliac disease

Be as exacting of your chiropodist, in cleanliness and sanitation, as you are with your manicurist, barber, waitress and physician

Because his feet hurt and no one would buy him a new pair of shoes, a beggar was complaining bitterly, when he saw another man, whose legs were paralyzed and deformed by infantile paralysis, offering prayers for the fact that his life had been spared.

A pair of rigid flat feet have less rhythm and grace than a pair of artificial feet and in addition the flat feet are painful.

Your standing position and your walking and running gaits are as characteristic as your mind and reflect your health and intelligence.

Foot rhythm means better mental rhythm.

Better feet mean keener wit.

Better balance below the knees means better balance above the collar bone.

Better poise means less noise.

Wear shoes that fit your feet—wear hose that are a little large.

Cut your toe nails straight across—do not cut corners unless you are a ballet dancer.

Bathe your feet daily.

Dry your feet as thoroughly as you dry your face.

Powder your toes if they perspire.

Walk with a heel-to-toe rhythm.

Grasp the ground with your toes as you walk.

Sit with your feet flat on the ground—never rest on your toes.

Elevate your feet for a few minutes several times during the day, to lessen the strain on your circulation.

The foot is more than a pedal, stilt or a pedestal. It is a system of levers, muscles and tendons with automatic feed and oiling systems, that get out of order, like an automobile. Be on the lookout for trouble and have it corrected as soon as possible.

The foot is an automatic shock absorber that protects the brain and other organs.

Avoid a slouchy gait.

Work shoes for work. Play shoes for play. Dress shoes for dress.

Never accept shoes that have to be "broken in." Part of your foot will "break out" before you "break in" the shoe.

Always try on both shoes before you purchase them.

A foot while bearing weight may be one-half or one whole size larger than it is while sitting.

A shoe will never grow longer.

Every shoe deserves a shoe tree.

Beware of unscientific alarmists who attribute ridiculous extrapedal symptoms to foot troubles.

One of the greatest dangers to a diabetic is a new pair of shoes.

A diabetic should be the cleanest citizen in the community.

A diabetic should tell his chiropodist of his condition.

Many persons with 1 or 2 artificial legs walk more gracefully and comfortably than some people with 2 rigid flat feet

In the diagnosis of gout, one must have a suspicion because a searcher is more likely to find something of which he is thinking

Footnotes on Military Footsteps

Soldier! Watch your step
Soldier—guard your feet
Run-down heels are bad for the soldier's sole

The soldier's foot and ankle may make the difference between success or failure of the battle

Good foot care is good military insurance

The infantry is an important line of defense and offense

Socks can "make or break" the fit of the soldier's shoe

Proper pedicure of the soldier's foot is essential to marching comfort

The soldier's knee can be strengthened or weakened by his feet

The soldier's ability to march is determined by his feet and ankles

The soldier's foot may be the weak link in an otherwise strong chain

Statements to the contrary notwithstanding, an army still marches on its feet

So far as the soldier himself is concerned there is no substitute for good feet

Minor conditions may become major casualties unless they are cared for in a serious way

OLD SHOES

How much a man is like old shoes!
For instance, each a soul may lose
Both have been tanned, both are made tight
By cobblers Both get left and right
Each needs a mate to be complete,
And both are made to go on feet
They both need healing, they both get sold,
And both in time turn all to mould
With shoes the last is first, with men
The first shall be the last, and when
The shoes wear out they're mended new,
When men wear out they're men dead, too
They both are trod upon, and both
Will tread on others, nothing loth,
Both have their ties, and both incline,
When polished, in the world to shine,
And both peg out—Now, would you choose
To be a Man, or be his shoes?—M C DODGE

Many short walking sessions daily, but many more long periods of rest, *preferably* in the supine posture are recommended.

In dislocations remember.

"Nature *smooths* things over
but she cannot *move* things over."

A club-foot that has been completely corrected will not relapse, unless injured and treated improperly.

Beware of the almost completely corrected club-foot.

Many a pediatrician's face has been reddened by neglect of a mild club-foot.

The disability of a stable, painless ankylosed joint is much less than that incident to an unstable, painful ankle with a limited degree of motion. (Boyd.)

Tout vaux mieux que l'infection. Anything is better than infection —Leriche.

The *relapsed* club-foot was never a *cured* club-foot.

A Blucher shoe is a type of half boot named after the Prussian General, Blucher. A shoe in which the quarters extend a short distance over the vamp, their inner edges being loose and lacing across the tongue.

On a hunting trip during "leave" a *right*-handed soldier is apt to shoot off the forepart of his *left* forefoot."

Fractures that involve the subastragalar joint cause a state of vulnerability to strains and sprains to such acts as stepping on a cobble stone.

The fractures which cause most trouble are:

1. Those that are not recognized.
2. Those that are mistreated.

Trench foot occupies a clinical position between frostbite and immersion foot.

Immobilize: (1) the wound; (2) the limb; (3) the patient.

Never immobilize a limb or part of a limb in a position of maximum correction.

It is okay to over-correct, but then one should permit some relaxation. When a member is over-corrected and immobilized there is immediately set up the factor that produces a battle between the forces for correction and deformity.

Out on a limb
or
On a limb that is out.

A painful heel should be cured before a roentgen-ray reveals a bony spur.

The size of the calcaneal spur does not determine its surgical removal.

A midget may be sicker than a giant.

Roentgen-rays are often misleading They must be interpreted by an expert in bone pathology

It is not simply a matter of the total number of units of penicillin—it is just as much a matter of timing and time spread

Under the most favorable conditions fractures of the ankle almost always leave deformity and lameness, which render progress difficult or painful—Dupuytren

In all serious injuries prepare for what your experience teaches you might happen, i e, shock and infection

In os calcis crush fractures the outlook for return of normal form is poor However, the possibility of good function may be surprisingly good

Crushing injuries of the foot and ankle often do surprisingly well when normal form is remolded and alignment is restored

In septic lesions of the foot and ankle it makes little difference what solution is used for irrigation, it is a matter of gallons not minutes

A *warming up* process is important in the prevention of sprains, strains, tears and rupture

Before you treat an injury of the ankle by procaine injection or ethyl chloride spray, be sure there is no fracture or dislocation

A nocturnal leg cramp can usually be dissipated by stepping on a cold surface such as the bedroom floor or the bathroom floor

Roengten-ray films are often very deceptive

Do not be misled by a negative roentgen-ray negative

Two negatives may make a positive diagnosis

In a consideration of the soldier's feet, minor care may prevent major troubles

Blisters Are more important than flat feet in causing disability on a march, because of the danger of infection . Blisters keep a soldier off duty more hours and days than flat feet A soldier can march long distance with flat feet but not with blisters

The old adage of Napoleon that "A soldier travels on his stomach" is outdated

No matter how good a foot is, it can be broken down by too heavy a load or too long a march, especially at the beginning of training

Your shoes Do they fit, or do they give you fits?

Your shoes Do they make or break your step?

Shape *vs* Fit How do your feet shape up in the shape and fit of your shoes?

A heavy sock is a great equalizer of size and fit and irregularities

Don't break down a good foot trying to make a good soldier too fast

Always dry the space between 4th and 5th toes before putting on your socks

Every doctor's office should have an assortment of crutches and canes with rubber tips.

You meet the world with your shoes and your feet are inside.

Do not be in a hurry to amputate, but when the procedure is inevitable, do not procrastinate.

If your little boy has poor feet, remember: he will have to carry them throughout his life, they will have to carry him through life; maybe they will fail—therefore, have them corrected as soon as possible.

"Never" cover metatarso-phalangeal joints.

You must have a good reason for including them.

Nine-tenths of wisdom is being wise in time—Theodore Roosevelt.

The most serious cause of interruptions of treatment in World War II was the evacuation of patients from one hospital to another over long lines of communications, finally terminating in a voyage overseas.

The general's wife might have a bedroom fracture.

The general's daughter might have a ballet-dancer's fracture of her fifth metatarsal.

A good result may help a young orthopædic surgeon get a promotion.

Soldiers fight better if they know, that if, as and when they are wounded, they will have good surgical care.

A wounded soldier is a wounded man twenty-four hours a day and may need good nursing care every minute.

Not all perfect reductions are followed by perfect limbs. A corollary to this is that not all imperfect reductions are followed by poor function.

Reduction vs. Alignment.

> Opportunity knocks at every fracture's door.
> It knocks once and may not knock anymore.

You don't have to walk on the roentgen-ray.

A plaster cast protects the patient against the inquisitive peeping surgeon.

A splint is only as good as the splinter.

A perfect reduction is not always imperative.

Some of the strongest bony unions I ever saw, had overriding (but good alignment).

Angulation predisposes to a poor result.

Immobilization is the most important consideration.

Advice to patients: Don't let the shoe man fool you into "breaking in" a pair of shoes. If you do, your feet will "break out" before you "break in" the shoes.

The Army may "travel on its stomach" but the individual soldier "marches on his feet."

Never stand if you can sit.

Never sit if you can lie down

Regarding stairs Always walk down but don't walk up

Are you a trooper or a drooper?

Are you foot conscious?

You should not be more conscious of your feet than you are of your breathing

There is no single military duty that pays the soldier such big dividends as the minor care of his feet

Minor care of the feet may prevent major troubles

Blisters are more important than flat feet in causing disability on the march Moreover blisters are gateways to serious infection

A soldier can march with third degree flat feet but not with first degree blisters

One pair of feet must last a soldier's lifetime

Many a good foot has been ruined by misuse

There are many feet that can march 10 miles every day for months, but may be ruined by marching 20 miles one day

The foot that hikes and hikes today, but in graduated distances, will stand up to hike and hike many another day, longer distances

Change socks on a long march

Beware, the moment you become foot conscious

Standard equipment for every soldier should include

Band-aid with sulfathiazole

An extra pair of socks

If there is truth in the statement "Cleanliness is indeed next to Godliness," it is in the feet, and especially in the feet of diabetics

The civilized man has built a coach but has lost the use of his feet (Emerson)

The fractures which cause most trouble are (1) those unrecognized, and (2) those mistreated

The dislocations which cause most trouble are (1) those unrecognized, and (2) those almost completely reduced

The surgeon must have a good reason for including the metatarsophalangeal joints

Do not break down a pair of good feet trying to make a good soldier too fast

Every soldier and athlete should carry at least one band-aid for immediate treatment of an incipient blister

The philosopher must first put aside his egotism, for how can a person learn what he thinks he already knows? (Epictetus)

Health is that precious heritage
Of priest and layman, fool and sage
It's worth a hundred times its cost
But no one learns that 'til its lost—Sheperd

If you would not be forgotten as soon as you are dead, either write things worth reading or do things worth writing (about). (Benjamin Franklin.)

There is no substitute for:

1. Brains	3. Experience
2. Hard work	4. Honest effort

The benefits derived from physiological treatment become an integral part of the person. They cannot be taken away from him except by neglect, misuse, abuse, infection or injury.

Shoes are miniature torture chambers (Baer.)

All men are equal if they walk far enough. (Baer.)

It was in the galleries and museums of Europe that man and woman first discovered museum feet which were later to be known as World's Fair feet.

Many women can be fitted better with men's or boys' shoes than with the modern women's shoe.

There are 2 ends to each of your legs; if 1 end deviates, something will surely happen to the other end. (Lowman.)

To solve a difficult problem, one should resolve it into simple components and attack each part.

THE RELATIONSHIP OF FOOT AND ANKLE CONDITIONS TO UROLOGY, GYNECOLOGY, AND OBSTETRICS

In this section I shall discuss briefly the relation of foot and ankle disturbances to urology, gynecology and obstetrics

Urology —The specialties of orthopædic and urological surgery have several conditions in common These are especially gonorrheal, syphilitic and tuberculous The most important genito-urinary complications which the orthopædic surgeon is called upon to treat include tuberculosis, arthritis and calcaneal spurs The important metastatic lesions are gonorrheal, tuberculous and neoplastic

Gonococcus infection may involve the bones and soft tissues of the foot A large number of patients suffering from rheumatic conditions have residual gonococcus infections in the genito-urinary tract especially the Fallopian tubes, urethra, Bartholin glands, seminal vesicles, and prostate

Gonorrheal arthritis is especially prone to affect the ankle and foot joints Calcaneal spurs are discussed on page 250

The treatment of the acute condition from the urological standpoint involves the general and local management General treatment consists of maintaining active resistance on the part of the patient and the use of vaccines and other specific and non-specific measures Some authorities report excellent results in the acute cases following foreign protein therapy Some prefer to use typhoid rather than specific gonococcus vaccine Specific chemotherapy with sulfanilamide and sulfapyridine is proving very successful Penicillin is specific

The great difficulty in eradicating infections of the genito-urinary tract is due to the fact that the bacteria have usually penetrated deeply into the tissues and glands beyond the urinary passages

On this account, injections and irrigations frequently fail to eradicate the infection

Gram-positive coccus infections of the kidneys and bladder have been eradicated by intravenous injections of neoarsphenamine Bacillary infections of the urinary tract have been shown to be especially resistant, but cases have responded favorably to intravenous injections of mercurochrome

Local injections and irrigations in urinary infections have been supplemented by intravenous therapy

The author has seen patients with profuse urethral discharge and acute arthritis of the elbow, wrist and knee clear up entirely after four hyperpyrexia treatments

Tuberculosis of the foot and ankle joint may be secondary to tuberculosis of the genito-urinary tract. Many of these urological conditions are secondary to osseous lesions but more often the bone condition is secondary to the genito-urinary infection.

Many urologists feel that tuberculosis originates in the seminal vesicles. There are *some* who believe it originates in the epididymis, and others in the prostate. Most genito-urinary tuberculosis is secondary to some focus in the lung. The syphilitic conditions which are of interest to the urologist and orthopædic surgeon are those which affect the bones and joints and the nerves especially, that is, periostitis, osteitis, trauma, Charcot's joint, myositis, fibrositis, tendinitis, and the neuropathies.

Gynecological aspects of foot and ankle disturbances include tumors of the pelvic viscera. Very often, following operations on these structures, the feet and ankles must be carefully guarded against unusual strain and the best prophylactic measure is a pair of high-laced shoes. Varicose veins, edema of the leg, deep phlebitis, and phlegmasia alba dolens may cause disturbances of the foot and ankle which require individual treatment. Bone conditions, osteomalacia, gonad disturbances, menopausal arthropathy, imbalance of the pelvis and inequality of the lengths of legs may have gynecological significance.

Obstetrical aspects of foot and ankle disturbances include varicose veins, obesity and pregnancy. The foot and ankle must be carefully guarded before, during, and after pregnancy. The most important prophylactic measure is a pair of high-laced shoes. In view of the fact that during pregnancy there is an increase in weight and because walking is the most important exercise for the pregnant woman, it is imperative that she wear proper shoes at all times. During pregnancy an infectious or toxic element may cause a lesion of the osteochondral tissue. This may progress to a state of destruction followed by ankylosis. The condition may be asymptomatic until delivery occurs, when severe pain and limitation of movement appear. Phlebitis is frequently associated with pregnancy. The most important factors in treatment are rest in bed, elevation of the entire limb and gentle even compression with an Ace, Adaptic Tensor or Tetra bandage, Lastex hosiery or a "gelocast" stocking.

Obstetrical Paralysis of the Peroneal Nerve.—According to A. Whitman, paralysis of the peroneal nerve from pressure upon the main trunk of the sciatic nerve in its intrapelvic portion may occur during prolonged or difficult labor, either from direct pressure by a large fetal head in a small pelvis, or from trauma by forceps.

Maternal Obstetrical Sciatic Paralysis.—Kleinberg states that maternal obstetrical sciatic paralysis rarely follows a severe labor in which a decided disproportion between the size and shape of the pelvis and

that of the fetal head is encountered, and in which extensive instrumentation has been employed. The paralysis is apparently due to an increase in the intrapelvic pressure causing trauma to the sciatic nerves. The symptoms usually appear immediately after delivery, but are at times delayed several days. They are bilateral and include motor and sensory changes. Drop-foot resulting from involvement of the external peroneal nerve is a conspicuous sign. It may disappear partially or completely, but at times may remain permanently. The treatment is entirely symptomatic and the prognosis must be guarded.

The new-born child becomes an orthopedic problem when he has dislocation of the hip, club-foot, bow-legs, torsion of the legs, defects of the bones or limbs, or a fracture. Treatment should begin at birth. It is grossly improper to wait until the infant is "older." The harmful effects of protracted "belly sleeping" are described elsewhere.

THE FOOT AND ANKLE IN BALLET, TAP, AND ACROBATIC DANCING

The foot and ankle of the ballet dancer are as important as the fingers of a violinist. They are subjected to often repeated minor and major strains. The chief troubles which occur especially in beginners are sprains, metatarsalgia, longitudinal arch strains and sesamoiditis.

Ballet shoes and slippers lend themselves to rubber or felt padding.

Every well-trained dancer knows that he or she must get to the theatre, concert hall or dancing studio ten or fifteen minutes early in order to "warm up," a process which implies more than its name indicates. It increases the local circulation and "loosens up" muscles, tendons, ligaments and fasciæ. The chief structures that suffer from strain are the adductors of the thighs, the hamstrings and the gastrocnemius muscles.

Each type of dancing has its own peculiar types of strain. The "stamping" in barefoot dancing predisposes to certain types of trauma especially to the metatarsal area.

OFFICE ACCESSORIES

Every physician's office, where feet and ankles are treated, should be supplied with:

- Large curved scissors
- Lead block
- Hammers
- Pliers
- Felt
- Knives
- Carborundum stone
- Sharpening steel
- Glue
- Cutting board
- Rubber cement
- Wood tongue depressors
- Articulated skeleton of foot
- Sliding ruler
- Percussion hammer
- Canes with rubber tips
- Crutches with rubber tips and axillary pads

In cases of inequality of lengths of legs, one should have wedges made of rubber or wood, of different sizes and heights such as $\frac{1}{4}$ inch, $\frac{1}{2}$ inch, $\frac{3}{4}$ inch, 1 inch and $1\frac{1}{2}$ inches. These are placed under the foot on the side of a short leg to balance the pelvis.

BIBLIOGRAPHY

ADAMS, J C Etiological Factors in Varicose Veins of the Lower Extremity, Surg Gynec and Obst, 69, 717-725, 1939

ALLEN, EDGAR V Chronic Occlusive Peripheral Arterial Diseases Read at the Fifty second Annual Meeting of the Association of Life Insurance Medical Directors of America, October 23-24, 1941

American Medical Association, Special Committee on Poliomyelitis Practical Suggestions on Poliomyelitis, Am Med Assn, Chicago, 1933

ANDERSON, ROGER New Waterproof Plastic Cast, Northwest Med, 43, 365, 1944

ANDERSON, R J The Presence of an Astragalo-Scaphoid Bone in Man, Jour Anat and Physiol, 14, 452, 1879

ANDERSON, R, and ERICKSON, H R Glass Plastic Cast, Am Jour Surg, Sept, 1945, N [redacted] Vol LXIX, No 3, p 299

ANSATT Subastragalar Dislocation of the Foot, Jour Bone and Joint Surg, 13, 574-577, July, 1931

ASHHURST, A C P, and BROMER, R S Classification and Mechanism of Fractures of the Leg Bones Involving the Ankle, Based on a Study of Three Hundred Cases From the Episcopal Hospital, Arch Surg, 4, 51, 1922

BERGER, L Synovial Sarcomas in Serous Bursæ and Tendon Sheaths, Am Jour Cancer, 34, 501, December, 1938

BERMAN, SAUL Complete Dislocation of Tarsal Scaphoid, Jour Am Med Assn, 83, 181-183, July 19, 1924

BERNSTEIN, A, and STONE, J B March Fracture—A Report of 307 Cases and a New Method of Treatment, Jour Bone and Joint Surg, 26, 743, October, 1944

BERNSTEIN, M A The Surgery of Tendon Transposition With Special Reference to the Importance of the Tendon Sheath, Surg, Gynec and Obst, 29, 55-69, July, 1919

——— The Clinical Aspect of Tendon Transplantation, Surg, Gynec and Obst, 34, 84-90, January, 1922

BETTS, L O Morton's Metatarsalgia Neuritis of Fourth Digital Nerve, Med Jour, Australia, I, 514, 1940

BICK, E M Fibrosarcoma of the Extremities, Ann Surg, 101 759, February, 1935

BICKEL, WM. H, and MOE, JOHN H Translocation of the Peroneus Longus Tendon for Paralytic Calcaneus Deformity of the Foot, Surg, Gynec and Obst, 78, 627-630, June, 1944

——— Source Book on Orthopædics, Baltimore, Williams & Wilkins, 1937

BLOUNT, W P Tibia Vara Osteochondrosis Deformans Tibiæ, Jour Bone and Joint Surg, 19, 1, January, 1937

BOHLER, L Diagnosis, Pathology and Treatment of Fractures of the Os Calcis, Jour Bone and Joint Surg, 13, 75, January 1931

——— Treatment of Fractures, Fourth English Edition, Trans by E W Hey Groves, Wm Wood & Co, Baltimore, 1935

BOHM M Der fötale Fuss Beitrag zur Entstehung des Pes planus, des Pes valgus und des Pes plano valgus, Ztschr f orthop, Chir, 57, 562, 1932, Der kindliche Fuss, Ztschr f orthop, Chir, 57, 84, 1932

BONNET WILLIAM L, and BAKER, D R Diagnosis of Pes Planus by X ray, Radiology, 46, 36-45, January, 1946

BOYD, H B Amputation of The Foot With Calcaneotibial Arthrodesis, Jour Bone and Joint Surg, 21, 997, October, 1939

——— Congenital Talonavicular Synostosis, Jour Bone and Joint Surg, 26 682-686, October, 1944

BOYD, H. B.: The Treatment of Malunited Fractures of the Ankle; Technic of Fusion of the Ankle; Am. Acad. Lectures on Reconstruction Surgery.
BOYD, HAROLD B., and KNIGHT, ROBERT A.: Fractures of the Astragalus, Southern Med. Jour., 35, 160, 1942.
BRANDT, GEORGE: Ergebn. d. Chir. u. Orthop., 33, 1-59, 1941. Abst. in Year Book of Radiology, p. 35 1941.
BROCKMAN, E. P.: Discussion, Proc. Royal Soc. Med. (Section of Orthop.), 23, 981-982, 1930.
——— Club-foot (Talipes Equinovarus), New York, William Wood & Co., 1930.
——— Modern Methods of Treatment of Club-foot, Brit. Med. Jour., 2, 572, September, 1937.
BROCKWAY, ALVA: Surgical Correction of Talipes Cavus Deformities, Jour. Bone and Joint Surg., 22, 81-91, January, 1940.
BROWN, JAMES B., and CANNON, BRADFORD: The Repair of Surface Defects of the Foot, Ann. Surg., October, 1944.
BROWNE, D.: Talipes Equinovarus, Lancet, 2, 969, November, 1934.
Bull. Am. Coll. Surg., Gas Gangrene, March, 1932.
Bull. Am. Med. Assn., Varicose Veins, Scientific Exhibit, Chicago, 1937.
BUNYAN, J.: Envelope Method of Treating Burns, Proc. Roy. Soc. Med., 34, 65, November, 1940.
BURMAN, MICHAEL S.: Subcutaneous Rupture of the Tendon of the Tibialis Anticus, Annals of Surgery, August, 1934.
BURMAN, M. S., and LAPIDUS, P. W.: The Functional Disturbances Caused by the Inconstant Bones and Sesamoids of the Foot, Arch. Surg., 22, 936, 1931.
BURMAN, and SINBERG: An Anomalous Talocalcaneal Articulation; Double Ankle Bones, 34, 239-240, February, 1940.
BURNS, B. H., and ELLIS, V. H.: Recent Advances in Orthopædic Surgery, London, J. & A. Churchill, 1937.
BUTTE, F. L.: Navicular-Cuneiform Arthrodesis for Flat-foot, Jour. Bone and Joint Surg., 19, 496, April, 1937.
CALLANDER, C. L.: Surgical Anatomy, Philadelphia, W. B. Saunders Company, 1939.
CAMPBELL, W. C.: An Operation for the Correction of "Drop-foot," Jour. Bone and Joint Surg., 5, 815, 1933.
——— Operative Orthopedics, St. Louis, C. V. Mosby Company, 1939.
——— An Operation for Induction of Osseous Fusion in the Ankle Joint, Am. Jour. Surg., 6, 588, May, 1929.
——— The Treatment of Malunited Fractures of the Ankle With Special Reference to Fusion, South. Surg., 7, 395, October, 1938.
CAMPER, P.: Dissertation sur les meilleures formes des souliers, Paris, 1781.
——— On the Best Form of Shoe, English trans. in Dowie, J., The Foot and Its Covering, London, 1861.
CARNEY, J. W.: Thiamine Hydrochloride for Cramps in Legs, Jour. Am. Med. Assn., April 22, 1944.
CASTELLANI, A.: Further Observations on Treatment of Epidermophytosis of the Toes by Fuchsin Paint, Jour. Trop. Med., 32, 77-79, March 15, 1929.
CHANG, C. C., and MILTNER, L. J.: Periostitis of the Os Calcis, Jour. Bone and Joint Surg., 16, 355, April, 1934.
CHRISTOPHER, FREDERICK: Textbook of Surgery, 4th ed., G. de Takáts, Chapter on Varicose Veins, Philadelphia, W. B. Saunders Company, 1945.
CLARK, C. W.: Traumatic Arterial Spasm, Brit. Med. Jour., II, 167, 1943.
CLARK, W. A.: A Rebalancing Operation for Pronated Feet, Jour. Bone and Joint Surg., 13, 867, 1931.
CLEVELAND, MATHER: Arch. Surg., 14, 1125, 1927.
COLLBROOK, LEON: Foreign Letters, Jour. Am. Med. Assn., 114, 1653, 1940.
COLLER, F. A., and FARRIS, J. M.: The Surgery of Modern Warfare, Surg., Gynec. and Obst., 72, 15, 1941.

COHN, H R Flat Foot and Extension Boot Heel, Jour Indust Hyg, 9, 77-84, March, 1927
——— The American Academy of Orthopedic Surgeons Lectures on Reconstruction of the Extremities Instructional Courses, edited by J E M Thomson, Ann Arbor, Mich, Edwards Bros, 1944
——— Fractures of the Os Calcis, Lectures on Reconstruction Surgery Ibid
CONWELL, H EARLE Flexo-extensometer, Surg, Gynec and Obst, 40, 710-711, January, 1925
COTTON, F J The Heel Shifting Operation for Flat Feet—and Others, New England Jour Med p 210, April 19, 1934
CREGO, C H, and McCARROLL, H R Recurrent Deformities in Stabilized Paralytic Feet, Jour Bone and Joint Surg, 20, 609, July, 1938
DANIELS, L, WILLIAMS, M, and WORTHINGHAM, C Muscle Testing Technics of Manual Examination, Philadelphia, W B Saunders Company, 1946
DAVIS, G G The Treatment of Hollow Foot (Pes Cavus), Am Jour Orthop Surg, 11, 231, 1913
——— Treatment of Poliomyelitis by Operative Measures, New York Med 119, 4, 1914
DAVIS, LOYAL, SCARFF, JOHNE, ROGERS, NEIL, and DICKINSON, MEREDITH High Altitude Frostbite Surg, Gynec and Obst, 77 561-575, December, 1943
DELORME, THOMAS L Restoration of Muscle Power by Heavy-Resistance Exercises, Jour Bone and Joint Surg, 27, 645-667, October, 1945
DE TAKATS, G Sympathectomy Arteriosclerosis Peripheral, Jour Am Med Assn, June 8, 1946
——— The Cutaneous Reactions to Histamine as a Test for Collateral Circulation in the Extremities, Arch Int Med, 48, 769, 1931
——— Causes of Failure in the Treatment of Varicose Veins, Jour Am Med Assn, 96, 1111, 1931
——— Vascular Anomalies of the Extremities, Surg, Gynec and Obst, 55, 227, August, 1932
——— Reflex Dystrophy of Extremities, Arch Surg, 34, May, 1937
——— Vascular Accidents of Extremities, Jour Am Med Assn, 110, 1075-1081, April 2, 1938
——— Nature of Painful Vasodilatation in Causalgic States, Arch Neurol and Psychiat, 50, 318, 1943
——— Causalgic States Following Injuries to the Extremities, Arch Phys Therapy, 24, 647, 1943
DE TAKATS, G, and MILLER, D S Posttraumatic Dystrophy of the Extremities, A Chronic Vasodilator Mechanism, Arch Surg, 46 469, 1942
DICKSON, FRANK D Fracture of the Ankle, Am Jour Surg, December, 1937
DICKSON and DIVELEY Functional Disorders of the Foot, Philadelphia, J B Lippincott Company, 1939
DITTRICH, R J Pathogenesis of Congenital Club-foot (Pes Equinovarus), Jour Bone and Joint Surg, 12, 373, April, 1930
DODD, HAROLD March Foot, Brit Jour Surg, 21, 131, July, 1933
DORLAND, W A N, and HUBENY, M J The X-ray in Embryology and Obstetrics, St Paul, Bruce Publishing Company, 1926
DUNN, H L The Statics of the Human Arch When Subjected to Body Weight, Milit Surg, LII 567, June, 1923
DUNN, N Stabilizing Operations in Paralytic Feet, Proc Roy Soc Med (Sect Orthop), 15, 15, 1922
——— Robert Jones Birthday Volume, London, Oxford University Press, 1928
DURHAM, H A A Procedure for the Correction of Internal Rotation of the Thigh in Spastic Paralysis, Jour Bone and Joint Surg, 20, 339-344, April, 1938
DWIGHT, T Clinical Atlas Variations of the Bones of the Hands and Feet, Philadelphia, J B Lippincott Company, 1907
EDWARDS, E A The Effect of Thrombophlebitis on the Venous Valve, Surg, Gynec and Obst, 65, 310-320, 1937

BOYD, H. B.: The Treatment of Malunited Fractures of the Ankle; Technique of Fusion of the Ankle; Am. Acad. Lectures on Reconstruction Surgery.
BOYD, HAROLD B., and KNIGHT, ROBERT A.: Fractures of the Astragalus, Southern Med. Jour., 35, 160, 1942.
BRANDT, GEORGE: Ergebn. d. Chir. u. Orthop., 33, 1-59, 1941. Abst. in Year Book of Radiology, p. 35 1941.
BROCKMAN, E. P.: Discussion, Proc. Royal Soc. Med. (Section of Orthop.), 23, 981-982, 1930.
——— Club-foot (Talipes Equinovarus), New York, William Wood & Co., 1930.
——— Modern Methods of Treatment of Club-foot, Brit. Med. Jour., 2, 572, September, 1937.
BROCKWAY, ALVA: Surgical Correction of Talipes Cavus Deformities, Jour. Bone and Joint Surg., 22, 81-91, January, 1940.
BROWN, JAMES B., and CANNON, BRADFORD: The Repair of Surface Defects of the Foot, Ann. Surg., October, 1944.
BROWNE, D.: Talipes Equinovarus, Lancet, 2, 969, November, 1934.
Bull. Am. Coll. Surg., Gas Gangrene, March, 1932.
Bull. Am. Med. Assn., Varicose Veins, Scientific Exhibit, Chicago, 1937.
BUNYAN, J.: Envelope Method of Treating Burns, Proc. Roy. Soc. Med., 34, 65, November, 1940.
BURMAN, MICHAEL S.: Subcutaneous Rupture of the Tendon of the Tibialis Anticus, Annals of Surgery, August, 1934.
BURMAN, M. S., and LAPIDUS, P. W.: The Functional Disturbances Caused by the Inconstant Bones and Sesamoids of the Foot, Arch. Surg., 22, 936, 1931.
BURMAN, and SINBERG: An Anomalous Talocalcaneal Articulation; Double Ankle Bones, 34, 239-240, February, 1940.
BURNS, B. H., and ELLIS, V. H.: Recent Advances in Orthopaedic Surgery, London, J. & A. Churchill, 1937.
BUTTE, F. L.: Navicular-Cuneiform Arthrodesis for Flat-foot, Jour. Bone and Joint Surg., 19, 496, April, 1937.
CALLANDER, C. L.: Surgical Anatomy, Philadelphia, W. B. Saunders Company, 1939.
CAMPBELL, W. C.: An Operation for the Correction of "Drop-foot," Jour. Bone and Joint Surg., 5, 815, 1933.
——— Operative Orthopedics, St. Louis, C. V. Mosby Company, 1939.
——— An Operation for Induction of Osseous Fusion in the Ankle Joint, Am. Jour. Surg., 6, 588, May, 1929.
——— The Treatment of Malunited Fractures of the Ankle With Special Reference to Fusion, South. Surg., 7, 395, October, 1938.
CAMPER, P.: Dissertation sur les meilleures formes des souliers, Paris, 1781.
——— On the Best Form of Shoe, English trans. in Dowie, J., The Foot and Its Covering, London, 1861.
CARNEY, J. W.: Thiamine Hydrochloride for Cramps in Legs, Jour. Am. Med. Assn., April 22, 1944.
CASTELLANI, A.: Further Observations on Treatment of Epidermophytosis of the Toes by Fuchsin Paint, Jour. Trop. Med., 32, 77-79, March 15, 1929.
CHANG, C. C., and MILTNER, L. J.: Periostitis of the Os Calcis, Jour. Bone and Joint Surg., 16, 355, April, 1934.
CHRISTOPHER, FREDERICK: Textbook of Surgery, 4th ed., G. de Takáts, Chapter on Varicose Veins, Philadelphia, W. B. Saunders Company, 1945.
CLARK, C. W.: Traumatic Arterial Spasm, Brit. Med. Jour., II, 167, 1943.
CLARKE, W. A.: A Rebalancing Operation for Pronated Feet, Jour. Bone and Joint Surg., 13, 867, 1931.
CLEVELAND, MATHER: Arch. Surg., 14, 1125, 1927.
COLPFRBOOK, LEON: Foreign Letters, Jour. Am. Med. Assn., 114, 1683, 1940.
COLLER, F. A., and FOBBES, J. M.: The Surgery of Modern Warfare, Surg., Gyn. and Obs., 72, 15, 1941.

CONN, H R Flat Foot and Extension Boot Heel, Jour Indust Hyg, 9, 77 84, March, 1927

——— The American Academy of Orthopædic Surgeons Lectures on Reconstruction of the Extremities Instructional Courses, edited by J E M Thomson, Ann Arbor, Mich, Edwards Bros, 1944

——— Fractures of the Os Calcis, Lectures on Reconstruction Surgery, Ibid

CONWELL, H EARLE Flexo-extensometer, Surg, Gynec and Obst, 40 710-711, January, 1925

COTTON, F J The Heel Shifting Operation for Flat Feet—and Others, New England Jour Med p 210, April 19, 1934

CREGO, C H, and McCARROLL, H R Recurrent Deformities in Stabilized Paralytic Feet, Jour Bone and Joint Surg, 20, 609, July, 1938

DANIELS, L, WILLIAMS M, and WORTHINGHAM, C Muscle Testing Technics of Manual Examination, Philadelphia, W B Saunders Company, 1946

DAVIS, G G The Treatment of Hollow Foot (Pes Cavus), Am Jour Orthop Surg, 11, 231, 1913

——— Treatment of Poliomyelitis by Operative Measures, New York Med, 119, 4, 1914

DAVIS, LOYAL, SCARFF, JOHNE, ROGERS, NEIL, and DICKINSON, MEREDITH High Altitude Frostbite Surg Gynec and Obst, 77 561-575, December, 1943

DeLORME, THOMAS L Restoration of Muscle Power by Heavy-Resistance Exercises, Jour Bone and Joint Surg, 27, 645-667, October, 1945

DE TAKÁTS, G Sympathectomy Arteriosclerosis Peripheral, Jour Am Med Assn, June 8, 1946

——— The Cutaneous Reactions to Histamine as a Test for Collateral Circulation in the Extremities Arch Int Med, 48 769, 1931

——— Causes of Failure in the Treatment of Varicose Veins, Jour Am Med Assn, 96, 1111, 1931

——— Vascular Anomalies of the Extremities, Surg, Gynec and Obst, 55, 227, August, 1932

——— Reflex Dystrophy of Extremities, Arch Surg 34 May, 1937

——— Vascular Accidents of Extremities, Jour Am Med Assn, 110, 1075-1081, April 2, 1938

——— Nature of Painful Vasodilatation in Causalgic States, Arch Neurol and Psychiat, 50, 318, 1943

——— *Causalgic States Following Injuries to the Extremities*, Arch Phys Therapy, 24, 647, 1943

DE TAKÁTS, G, and MILLER, D S Posttraumatic Dystrophy of the Extremities, A Chronic Vasodilator Mechanism, Arch Surg, 46, 469, 1942

DICKSON, FRANK D Fracture of the Ankle Am Jour Surg, December, 1937

DICKSON and DIVELEY Functional Disorders of the Foot, Philadelphia, J B Lippincott Company, 1939

DITTRICH, R J Pathogenesis of Congenital Club-foot (Pes Equinovarus), Jour Bone and Joint Surg, 12, 373, April, 1930

DODD, HAROLD March Foot, Brit Jour Surg, 21, 131, July, 1933

DORLAND, W A N, and HUBENY, M J The X-ray in Embryology and Obstetrics, St Paul, Bruce Publishing Company, 1926

DUNN, H L The Statics of the Human Arch When Subjected to Body Weight, Milit Surg, LII 567 June, 1923

DUNN, N Stabilizing Operations in Paralytic Feet, Proc Roy Soc Med (Sect Orthop), 15, 15, 1922

——— Robert Jones Birthday Volume, London Oxford University Press, 1928

DURHAM, H A A Procedure for the Correction of Internal Rotation of the Thigh in Spastic Paralysis, Jour Bone and Joint Surg, 20, 339-344 April, 1938

DWIGHT, T Clinical Atlas Variations of the Bones of the Hands and Feet, Philadelphia J B Lippincott Company, 1907

EDWARDS, L A The Effect of Thrombophlebitis on the Venous Valve, Surg, Gynec and Obst, 65 310-320, 1937

ELMSLIE, R. C.: The Principles of Treatment of Congenital Talipes Equino-varus, Jour. Orthop. Surg., 2, 669, December, 1920.

ELWARD and OFFILL: Subastragaloid Dislocation of the Foot, Radiology, 14, 71-72, January, 1930.

ERLACHER, P. J.: Die Technick des orthopædischen Eingriffs. Eine Operationslehre aus dem Gesamtgebiet der Orthopædie, Vienna, Julius Springer, 1928.

EYCLESHYMER, A. C., and JONES, T.: Hand-Atlas of Clinical Anatomy, Philadelphia, Lea & Febiger, 1925.

FEISS, H. O.: Radical Treatment of Deformity Following Old Fracture of the Lower Epiphysis of the Tibia, Surg., Gynec. and Obst., 8, 583-587, August, 1909.

FERGUSON, A. B.: Roentgen Diagnosis of the Extremities and Spine, New York, Paul B. Hoeber, Inc., 1939.

FETTERMAN, J. L., and SPITLER, D. K.: Vascular Disorders of Peripheral Nerves, Jour. Am. Med. Assn.,

FITZGERALD, F. P., and SEDDON, H. J.: Lambrinudi's Operation for Drop-foot, Brit. Jour. Surg., 25, 283, October, 1937.

FORRESTER-BROWN, M.: The Treatment of Congenital Club-foot (Equinovarus), Jour. Bone and Joint Surg., 17, 661, July, 1935.

FRASER, J.: Minor Orthopædics of the Feet in General Practice, Brit. Med. Jour., 1, 383, March, 1929.

FREIBERG, A. H.: The So-called Infraction of the Second Metatarsal Bone, Jour. Bone and Joint Surg., 8, 257, April, 1926.

FREUND, E.: Congenital Defects of Femur, Fibula and Tibia, Arch. Surg., 33, 349, September, 1936.

GAGE, MIMS: Mycotic Aneurysm of the Common Iliac Artery; Sympathetic Ganglion Block as an Aid in the Development of the Collateral Circulation in Arterial Aneurysm of the Peripheral Arteries, Trans. So. Surg., Assn., 46, 137, 1934.

GAMM, KENNETH E.: Arteriovenous Fistula, Jour. Am. Med. Assn., 119, May, 1942.

GESCHICKTER, C. F., and COPELAND, M. M.: Tumors of Bone, New York, Am. Jour. Cancer, 2d ed., 1936.

GESCHICKTER, C. F., and MASERITZ, I. H.: Affections of Muscles, Jour. Bone and Joint Surg., 21, 576, July, 1939.

GILL, A. B.: Surgery of the Foot in Infantile Paralysis, Am. Jour. Surg., 44, 252, April, 1939.

———: Stoffel's Operation for Spastic Paralysis, Jour. Orthop. Surg., 3, 52, February, 1921.

———: An Operation to Make a Posterior Bone Block at the Ankle to Limit Foot-drop, Jour. Bone and Joint Surg., 15, 166, 1933.

GIRDLESTONE, G. R.: Closed Plaster Treatment of Infected Wounds, Lancet, 2, 31, July 13, 1940.

GLEICH, A.: Beitrag zur Operativen Plattfuss-behandlung, Arch. f. klin. Chir., 46, 368, 1893.

GOLDTHWAIT, J. E.: Operation for Stiffening of the Ankle Joint in Infantile Paralysis, Am. Jour. Orthop. Surg., 5, 71, 1908.

GRAHAM, J.: The Treatment of Gout, Proc. Roy. Soc. Med. (Sect. Therap. and Pharmacol.), 20, 1, 1937.

———: Weak Foot: Pathogenesis and Treatment, Am. Jour. Surg., 35, [illegible], March, 1937.

GREENE, R.: Frostbite and Kindred Ills, Lancet, 2, 689-693, 1941.

GRODINSKY, MANUEL: A Study of the Fascial Spaces of the Foot and Their Bearing on Infections, Surg., Gynec. and Obst., 49, 737-751, 1929.

———: Study of Tendon Sheaths of Foot and Their Relation to Infection, Surg., Gynec. and Obst., 51, 460, October, 1930.

GUIBAL, A., and GREGOIRE, J.: Peut-on éviter la contaminatin de [illegible] tion de Chopart? Rev. de chir., Paris, 59, 673, 1920.

HAAS, S L An Operation for the Correction of Hallux Varus, Jour Bone and Joint Surg, **20**, 705–708, July, 1938

HAGGART, G E Significance of Contracted Calf Muscles in Mechanics of Foot Strain, Surg Clin North America, **11**, 371 April, 1931

HALL, F C Menopausal Arthralgia, New England Jour Med, **219**, 1015, December, 1938

HAMSA, W R Hallux Valgus Study of End Results of 339 Bunionectomies Nebraska State Med Jour, **22**, 225, June, 1937

HARMON, P H, and FAHEY, J J The Syndrome of Congenital Absence of the Fibula, Surg, Gynec and Obst, **64**, 876, May, 1937

HARRIS, R I The Effect of Lumbar Sympathectomy Upon the Growth of Legs Paralyzed by Anterior Poliomyelitis, Jour Bone and Joint Surg, **18**, 35, January, 1936

HART, A J War Surgery in Spain, Brit Med Jour, **1**, 1099, 1146, 1939

HART, V L Arthrodesis of Foot in Infantile Paralysis, Surg, Gynec and Obst, **64**, 794–805, April, 1937

HART, VERNON L Arthrodesis of Foot and Ankle in Military Surgery, Lectures on Reconstruction Surgery of the Extremities, American Academy of Orthopædic Surgeons, edited by J E M Thomson, Ann Arbor, Mich, Edwards Bros, 1944, page 301

HASS, J Welche von den zahlreichen Operationsmethoden beim Hallux valgus sollen wir anwenden? Zentralbl f Chir, **26**, 1561–1564, 1932

HAUSER, E D W Surgery of Minor Foot Conditions, Surg Clin North America, **18**, 85–111, February, 1938

HENCH, P S Diagnosis and Management of Gout, Proc Staff Meet Mayo Clinic, **12**, 262, April 28, 1937

——— Diagnosis and Treatment of Gout and Gouty Arthritis, Jour Am Med Assn, **116**, 453, February 8, 1941

HENDERSON, M [redacted] Pseudarthrosis of the Tibia in Children, Jour Bone and Joint Surg, **7**, 340, April, 1925

HENDERSON, M S, and STUCK, W G Fractures of the Ankle Recent and Old, Jour Bone and Joint Surg, **15**, 882, October, 1933

HERTZLER, A E Bursitides of the Plantar Surface of the Foot Am Jour Surg, **1**, 117, September, 1926

HEYERDALE, WILLIAM W, and STALKER, LEONARD Management of Varicose Veins of the Lower Extremities, Ann Surg, **114**, December, 1941

HEYMAN, C H Manipulation of Joints, Jour Bone and Joint Surg, **12** 23, January, 1930

——— The Surgical Treatment of Spastic Paralysis, Surg Gynec and Obst **68**, 782, April, 1939

HAMILTON, J F Osteoid Osteoma, With Case Reports, Surg, Gynec and Obst, **81**, 465, 1945

HINES, Jr, EDGAR A, and BARKER, NELSON W Arteriosclerosis Obliterans, Am Jour Med Sci, **200**, 717, 1940

HIRSHFELD, JOHN W, WILLIAMS, HAROLD H, ABBOTT, WILLIAM E, HELLER, CARL G, and PILLING, MATTHEW A Significance of the Nitrogen Loss in the Exudate From Surface Burns, Surgery, **15**, 766–773, 1944

HISS, J M Hallux Valgus, Its Cause and Simplified Treatment, Am Jour Surg, **11**, 51–57, 1931

HOFFMANN, P Conclusions Drawn From a Comparative Study of the Feet of Barefooted and Shoe-wearing Peoples, Am Jour Orthop Surg, **3** 105–136 1905

HOHMANN, GEORG Fuss und Bein ihre Erkrankungen und deren Behandlung 2 Aufl, S 239 Munich, J F Bergmann, 1934

HOKE, M An Operation for the Correction of Extremely Relaxed Flat Feet, Jour Bone and Joint Surg, **13**, 773, 1931

——— An Operation for Stabilizing Paralytic Feet, Am Jour Orthop Surg, **3**, 494, 1921

HOLLAND, C. THURSTON: The Accessory Bones of the Foot With Notes on Other Conditions, Robert Jones Birthday Volume, p. 157, Oxford University Press, 1928.
HOMANS, JOHN: Circulatory Diseases of the Extremity, MacMillan Co., N. Y., 1939.
———— A Textbook of Surgery, Springfield, 6th Ed., Charles C Thomas, 1945
HORN, CARL E.: Acute Ischæmia of the Anterior Tibial Muscle and the Long Extensor Muscles of the Toes, Jour. Bone and Joint Surg., 27, No 4, 615, October, 1945.
HORTON, B. T.: Intermittent Claudication in the Extremities With Pulsating Vessels, Med. Clin. North America, 14, 783, 1930.
HORWITZ, THOMAS: Ischemic Contracture of the Lower Extremity, Arch. Surg., 41, 945, 1940.
HOWARD, N. J.: Peritendinitis Crepitans. A Muscle-Effort Syndrome, Jour. Bone and Joint Surg., 19, 447, April, 1937.
HSIEH, C. K., MILTNER, L. J., and CHANG, C. P.: Tuberculosis of the Shaft of the Large Long Bones of the Extremities, Jour. Bone and Joint Surg., 16, 545, 1934.
HUNTER, CHARLES: Cramp of Calf Muscles, International Clinics, Vol IV, Series 42.
ILFELD, FREDERIC W.: Pes Planus; Military Significance and Treatment With Simple Arch Support,
INGE, G. A. L., and FERGUSON, A. B.: Surgery of the Sesamoid Bones of the Great Toe, Arch. Surg., 27, 466, September, 1933.
JACK, E. A.: The Ætiology of Hallux Rigidus, The British Journal of Surgery.
JANSEN, MURK: March Foot, Jour. Bone and Joint Surg., 8, 262, April, 1926.
JENKINSON, E. L., and LEWIN, P.: Bone Diseases in Infancy and Childhood, Am. Jour. Roentgenol., 17, 201, February, 1927.
JONES, E.: Operative Treatment of the Chronic Dislocation of the Peroneal Tendons, Jour. Bone and Joint Surg., 14, 574, July, 1932
JONES, G. BLUNDELL: Pathology of Ruptured Plantaris, Brit. Med. Jour., 876, June 23, 1946.
JONES R.: Notes on Military Orthopædics, London, Cassel & Co., 1917.
———— Orthopædic Surgery of Injuries, London, Oxford Univ. Press, 1, 1921.
JONES, R., and LOVETT, R. W.: Orthopedic Surgery, New York, William Wood and Co., 1929.
JONES, R. W., and ROBERTS, R. E.: Calcification, Decalcification and Ossification, Brit. Jour. Surg., 21, 461, January, 1934.
JORDAN, W. R.: Neuritic Manifestations in Diabetes Mellitus, Arch. Int. Med., 57, 307, 1936.
JOSLIN, E. P.: A Diabetic Manual, Philadelphia, Lea & Febiger, 1941.
JUVARA, E.: Le Hallux-Valgus: Son Traitement Opératoire, Rev. d. Chir., 51, 322-348, 1932
KAHLSTROM, S. C., BURTON, C. C., and PHEMISTER, D. B.: Aseptic Necrosis of Bone, Surg., Gynec. and Obst., 68, 129, 631, February and March, 1939
KAHN, FRITZ: Man—Its Structure and Function, New York, A. A. Knopf, 1943
KAMPMEIER, O. F., and BIRCH, C.: The Origin and Development of Venous Valves With Particular Reference to the Saphenous District, Anat. Rec., 38, 451-499, 1927.
KARP, M. G.: Köhler's Disease of the Tarsal Scaphoid: An End-result Study, Jour. Bone and Joint Surg., 19, 84, January, 1937.
KEITH, A.: Notes on a Theory to Account for the Various Arrangements of the Flexor Profundus Digitorum in the Hand and Foot of Primates, Jour. Anat. and Physiol., 28, 335, 1894.
———— Menders of the Maimed, London, Oxford Univ. Press, 1919.
———— Hunterian Lectures on Man's Posture: Its Evolution and Disorders, Brit. Med. Jour., 1, 451-499-545-587 624-669, 1923.
———— The Gorilla and Man as Contrasted Forms, Lancet, 1, 490, 1926
———— History of the Human Foot, Jour. Bone and Joint Surg., 11, 10, 1929.

KELLER, W L New York Med Jour, 80, 741–742, 1904
——— Further Observations on the Surgical Treatment of Hallux Valgus and Bunions, New York Med Jour, 95, 696, April, 1912
——— The Surgical Treatment of Bunions and Hallux Valgus, New York Med Jour, 80, 741, 1904
KELLY Osteomyelitis, Jour Bone and Joint Surg, October, 1946
KENNEDY, R H Amputations General Considerations, Surg Clin North America, 18, 257–296, April, 1938
KEY, J A, and CONWELL, H E The Management of Fractures, Dislocations and Sprains, St Louis, The C V Mosby Company, 1938
KEY, J A, FISCHER, F, and ELZINGA, E Local Atrophy of Bone, Effect of Immobilization and Operative Procedures, Arch Surg, 28 936 May, 1934
KIDNER, F C The Prehallux (Accessory Scaphoid) in Its Relation to Flat Foot, Jour Bone and Joint Surg, 11, 831, October, 1929
KING, E S J Concerning the Pathology of Tumors of Tendon Sheaths, Brit Jour Surg, 18, 594, April, 1931
——— Localized Rarefying Conditions of Bone, Baltimore, William Wood & Company, 1935
KIRK N T Amputation Stumps of Lower Extremity, Jour Bone and Joint Surg, 15, 101–111, January, 1933
KITE, J H Congenital Pseudarthrosis of the Tibia and Fibula, South Med Jour, October, 1941
——— Non-operative Treatment of Congenital Club-foot, South Med Jour, 23, 337, April, 1930
——— Treatment of Congenital Club feet, Surg, Gynec and Obst 6, 190, 1935
——— Principles Involved in the Treatment of Congenital Club foot, Jour Bone and Joint Surg, 21, 595–606, 1939
KLEINBERG, SAMUEL The Operative Care of Hallux Valgus and Bunion, Am Jour Surg, 15, 75, 1936
——— The Operative Cure of Hallux Valgus and Bunions, Am Jour Surg, 15, 75–81, 1932
KOCH, S J The Transplantation of Skin and Subcutaneous Tissue (Part II), Surg, Gynec and Obst, 72, 157, February, 1941
KOHLER, A Typical Disease of the Second Metatarsophalangeal Joint Am Jour Roentgenol, 10, 705, September, 1923
KULOWSKI, J, FRENCH, A M, and ERICKSON, H R Aire-lite, A New Plastic Medium of Clinical Immobilization, Am Jour Surg, 66 315 327, 1944
LAKE, N C The Foot, Baltimore, Williams & Wilkins Company, 3d ed, 1943
——— The Problem of Footwear, Practitioner, 156, 81 87, 1946
LAMBRINUDI, C New Operation for Drop-foot, Brit Jour Surg, 15, 193, October, 1927
LAPIDUS, P W Complete and Permanent Removal of Toenail in Onychogryposis and Subungual Osteoma, Am Jour Surg, 19, 92 94, January, 1933
——— Operative Correction of Metatarsus Varus Primus in Hallux Valgus, Surg, Gynec and Obst, 58 183, February, 1934
——— Transplantation of the Extensor Tendon for Correction of the Overdropping of the Fifth Toe,
——— Congenital Fusion of the Bones of the Foot, With a Report of a Case of Congenital Astragaloscaphoid Fusion, Jour Bone and Joint Surg, 14, 888, October, 1932
——— Congenital Unilateral Absence of the Medial Sesamoid of the Great Toe Report of a Case, Jour Bone and Joint Surg, 21 208 January, 1939
——— Operative Correction of the Metatarsus Varus Primus in Hallux Valgus, Surg, Gynec and Obst, 58, 183, 1934
——— Sesamoids Beneath All the Metatarsal Heads of Both Feet Report of Case, Jour Bone and Joint Surg, 22, 1059–1062, October 1940
——— Spastic Flat Foot Jour Bone and Joint Surg, 28, 126, 1946
——— Operation for Correction of Hammer-toe, Jour Bone and Joint Surg, 21, 977, October, 1939

LARREY, D. J.: Memoires de chirurgie militaire, et campagnes, 3, 499, Paris C. J. Smith, p. 60, 1812.

LARSEN, BERNARD B.: A Walking Iron for Immediate Use on Wet Plaster Casts Surg., Gynec. and Obst., 68, 1082–1084, 1939.

LEARMONTH, J. R., BLACKWOOD, W., and RICHARDS, R. L.: Localised Arterial Thrombosis of Indeterminate Origin, Edinburgh Med. Jour., 51, 1, 1944.

LE MESURIER, A. B.: The Methods Used in Handling the Epidemic of Poliomyelitis in Ontario in 1937, Jour. Bone and Joint Surg., 21, 867, October, 1939.

LERICHE, RENE: The Surgery of Pain (Trans. by Archibold Young), Baltimore, The Williams & Wilkins Co., p. 40, 1939.

LERICHE, R., FONTAINE, R., and DUPERTUIS, S. M.: Arterectomy With Follow-up Studies on 78 Operations, Surg., Gynec. and Obst., 64, 149, 1937.

LERICHE, R., FONTAINE, R., and MAITRE, R.: Résultats éloignes du traitement des ulcères de jambe par les operations sympathiques combinées aux greffes cutanées, d'après 52 observations, J. de chir., 46, 689–710, 1935

LERICHE, R., and POLICARD, A.: The Normal and Pathological Physiology of Bone, St. Louis, The C. V. Mosby Company, 1928.

LEWIN, P.: Congenital Absence or Defects of Bones of the Extremities, Am. Jour Roentgenol., 4, 431, September, 1917.

——— Juvenile Deforming Metatarso-phalangeal Osteochondritis, Jour. Am Med. Assn., 81, 189, 1923.

——— Do Your Feet Hurt? Hygeia, 3, 317–319, June, 1925.

——— Apophysitis of the Os Calcis, Surg., Gynec. and Obst., 41, 579–582, November, 1925.

——— Calcaneal Spurs, Arch. Surg., 12, 117–124, January, 1926.

——— Flat Foot in Infants and Children, Am. Jour. Dis. Child., 31, 701–718, May, 1926.

——— Ballet Dancing, Hygeia, March, 1927.

——— Disturbances of the Metatarsal Arch, Jour. Am. Med. Assn., 88, 994–998, March 26, 1927.

——— Improved Technic in the Application of Plaster-of-Paris Casts in the Treatment of Congenital Club Foot, Jour. Am. Med. Assn., 90, 1943, June 16, 1928.

——— The Ten Commandments of Good Posture, Hygeia, 6, 3–5, January, 1928

——— Posture and Hygiene of the Feet, The National Health Series edited by the National Health Council, New York, Funk & Wagnalls, p. 47, 1929.

——— Prescription Blank for Modification of Shoes, Jour. Bone and Joint Surg., 12, 668–669, July, 1930.

——— Principles and Practice of Physical Therapy, Hagerstown, W. F. Prior Company, 1932

——— A Nurse's Feet Deserve Good Care, Am. Jour. Nurs., 38, 35, April, 1938, Sec. II.

——— Relation of Arthritis to Dental Infection, Jour. Am. Dent. Assn., 19, 2140, February, 1932.

——— Textbook on Orthopædic Surgery for Nurses, 4d ed., Philadelphia, W. B. Saunders Company, 1947.

——— What About Your Child's Feet, Hygeia, p. 928, October, 1935.

——— The Foot and Ankle, Their Discomforts, Deformities and Disabilities, Minnesota Med., 21, 769, November, 1938.

——— Disturbances of the Metatarsal Arch, Am. Jour. Surg., 44, 305, April, 1939.

——— Christopher's Text-book of Surgery, Certain Foot Disorders, 4th ed., Philadelphia, W. B. Saunders Company, 1945.

——— Infantile Paralysis, W. B. Saunders Company, 1941.

LEWIS, D.: Peripheral Nerves, Practice of Surgery, vol. 3, Chap. 6, Hagerstown, W. F. Prior Company, Inc., 1929.

LEWIS, T Observations on Some Normal and Injurious Effects of Cold Upon the Skin and Underlying Tissues I Reactions to Cold, and Injury of Normal Skin, Brit Med Jour, 2, 795-797, 1941 II Chilblains and Allied Conditions, ibid 2, 837-839, 1941 III Frostbite, ibid 2, 869-871, 1941

LEWISON, EDWARD F Rayable Gauze as a Factor of Safety in Surgical Operations, Bull Am Coll Surg, 27, 39-40, 1942

LILLY, GEORGE D Alcohol Injection of Lumbar Sympathetic Trunk, Jour Am Med Assn, 128, June 16, 1945

LORD, J P Correction of Extreme Flatfoot, Jour Am Med Assn, 81, 1502, 1923

LOWENBERG, E L Acute Traumatic Arterial Thrombosis of the Extremities, Virginia Med Monthly, 67, 630, 1940

LOWMAN, C L An Operative Method for Correction of Certain Forms of Flatfoot, Jour Am Med Assn, 81, 1500, 1923

——— Underwater Gymnastics, Jour Am Med Assn, 97, 1074, October, 1931

——— Plaster-of-Paris Casts, An Experimental and Clinical Analysis, Jour Am Med Assn, 124, 23-29, 1944

LUCK, J VERNON Psychosomatic Problems in Military Orthopedic Surgery, Jour Bone and Joint Surg, January, 1946

MACEY, H B The Etiology and Treatment of Soft Corns Proc Staff Meet, Mayo Clin, 15, 549-550, August 28, 1940

MAGNUSON, P B Fractures, 4th ed, Philadelphia, J B Lippincott Company, 1942

MAHORNER, HOWARD Control of Pain in Post-traumatic and Other Vascular Disturbances The Role of the Sympathetic Nervous System in the Treatment of Peripheral Vascular Diseases, Ann Surg, 119, March, 1944

——— Control of Pain in Post-traumatic Vascular Diseases, Surg, Gynec and Obst, 78, 657 658, June, 1944

——— Sympathetic Nerve Blocks in Rehabilitation of the Injured Extremity, N O Med and Surg Jour, 94, 426-482, March, 1942

MALKIN, S A S Discussion on Spasmodic Flat foot, Proc Roy Soc Med (Section of Orthop), 23, 973-981, 1930

MANSON BAHR Manson s Tropical Diseases Stitts-Strong, Tropical Diseases, The Army Medical Bulletin and The Naval Medical Journal of the last two years

MASERITZ, I H March Foot Associated With Undescribed Changes of the Internal Cuneiform and Metatarsal Bones, Arch Surg, 32, 49-64, January, 1936

MASON, M Wound Healing, Illinois Med Jour, 78, 523, December, 1940

MAYER, L The Physiological Method of Tendon Transplantation, Surg, Gynec and Obst, 22, 182, 1916

——— The Physiological Method of Tendon Transplantation Surg, Gynec and Obst, 22, 298, 1916

——— The Physiological Method of Tendon Transplantation Surg, Gynec and Obst, 22, 472, 1916

——— The Physiological Method of Tendon Transplantation in the Treatment of Paralytic Drop-foot, Jour Bone and Joint Surg 19, 389, April, 1937

——— The Operative Treatment of Paralytic Deformities of the Foot, Am Jour Surg, 7, 80, 1929

——— Surgery of Tendons, The Cyclopedia of Med, Philadelphia, F A Davis, vol 12 1934

MAYO, C H The Surgical Treatment of Bunion, Ann Surg, 48, 300, August, 1908

MAZZINI, O F SILVEYRA REYES, A, and MONZO, A Ossifications in the Tendo Achilles A Peroneal Bone and Trochlear Apophysis of the Astragalus, Rev de ortop y traumatol, 5, 44, 1935

McBRIDE, E D Conservative Operation for Bunions, Jour Am Med Assn, 105, 1164, October 12, 1935

——— Disability Evaluation 3rd ed, Philadelphia, J B Lippincott Company, 1942

McBride, E. D.: A Conservative Operation for Bunions, Jour. Bone and Joint Surg., 10, 735, 1928.
McElvenny, Robert T.: The Etiology and Surgical Treatment of Intractable Pain About the Fourth Metatarsophalangeal Joint (Morton's Toe), Jour. Bone and Joint Surg., 25, 675-679, July, 1943.
McKechnie, R. E., and Allen, E. V.: Sudden Occlusion of the Arteries of the Extremity. A Study of 100 Cases of Embolism and Thrombosis, Proc. Staff Meet., Mayo Clinic, 10, 678, 1935.
McPheeters, H. O., and Rice, C. O.: Varicose Veins; Circulation of Venous Flow, Surg., Gynec. and Obst., 49, 29-33, 1929.
Meyerding, H. W., and Pollock, G. A.: March Fracture, Surg., Gynec. and Obst., 67, 234, August, 1938.
Meyerding, H. W., and Stuck, W. G.: Painful Heels Among Children (Apophysitis), Jour. Am. Med. Assn., 102, 1658, May, 1934.
Milch, Henry: Reinforcement of the Deltoid Ligament for Pronated Flat-foot; Inversion Fasciodesis of Os Calcis, Surg., Gynec. and Obst., 74, 876-881, 1942.
Miller, Donald, and de Takáts, Geza: Posttraumatic Dystrophy of the Extremity; Sudeck's Atrophy, Surg., Gynec. and Obst., 75, 558-582, 1942.
Miller, O. L.: A Plastic Flat-foot Operation, Jour. Bone and Joint Surg., 9, 84, 1927.
Mitchell, S. W.: On a Rare Vasomotor Neurosis of the Extremities and on the Maladies With Which it May Be Confounded, Am. Jour. Med. Sci., 76, 2-36, 1872.
Morton, D. J.: Evolution of the Human Foot, Am. Jour. Phys. Anthrop., 5, 305, 1922; 7, 1, 1924.
——— Evolution of the Longitudinal Arch of the Human Foot, Jour. Bone and Joint Surg., 6, 56, January, 1924.
——— Mechanism of the Normal Foot and of Flat-foot, Jour. Bone and Joint Surg., 6, 368, April, 1924.
——— Human Origin: Correlation of Previous Studies of Primate Feet and Posture With Other Morphologic Evidence, Am. Jour. Phys. Anthrop., 10, 173, 1927.
——— Hypermobility of First Metatarsal Segment, Jour. Bone and Joint Surg., 10, 187, April, 1928.
——— The Human Foot, New York, Columbia University Press, 1935.
——— Oh, Doctor! My Feet! New York, D. Appleton-Century Company, 1939.
Morton, D. J.: Jour. Am. Med. Assn., October 2, 1937.
Morton, J. J., and Scott, W. J. M.: The Quantitative Determination of Vasoconstrictor Spasm as a Basis for Therapy in Peripheral Arterial Diseases, Ann. Surg., 96, 754, 1932.
Morton, T. G.: On Cases of Painful Affection of the Foot, Ph[illegible] Times, October, 1886.
——— A Peculiar Affection of the Fourth Metatarso-ph[illegible] Am. Jour. Med. Sci., 1876.
Nickerson, Samuel Harold: March Fracture or Insu[illegible] Jour. Surg., New Series vol. 62, No. 2.
Nicholson, J. H., and Falk, A.: Night Cramps in You[illegible] Jour. Med., 233, 517-576, Boston, November 8, 1945.
Nicoll, E. A.: Principles of Exercise Therapy, Brit. Med. [illegible]
Noble, T. P., and Hauser, E. D. W.: Acute Bone Atrop[illegible] January, 1926.
Ober, F. R.: Tendon Transplantation in the Lower Ex[illegible] Jour. Med., 209, 52, July, 1933.
Ochsner, Alton, and DeBakey, Michael: Thrombop[illegible] Vasospasm in the Production of the Clinical Manife[illegible] Assn., 114, 123, January 13, 1940.
O'Donoghue, D. H., and Sell, L. S.: Congenital T[illegible] Jour. Bone and Joint Surg., 25, 925, October, 1943.

OGILVIE, W H Treatment of Wounds, Brit Med Jour, 1, 132, 183, 1938
——— Wound Infection, Lancet War Primer, London, 1940
ORMSBY, O S Diseases of the Skin, 7th ed, Philadelphia, Lea & Febiger, 1943
ORR, H W Fractures and Other Infected Wounds, St Louis, The C V Mosby Company, 1929
——— The Treatment of Acute Osteomyelitis by Drainage and Rest, Jour Bone and Joint Surg, 9, 733, October, 1927
PAGE, MAX Foreign Letters, Jour Am Med Assn, 114, 2387, 1940
PARK, E A Some Aspects of Rickets, Canad Med Assn Jour, 26, 3, January, 1932
PATTERSON, R F Multiple Sesamoids of the Hands and the Feet, Jour Bone and Joint Surg, 19, 531, April, 1937
PATTERSON, R H Paper presented Before the Association of Military Surgeons of the United States, Philadelphia, October 21-23, 1943
PEABODY, C W The Surgical Care of Hallux Valgus, Jour Bone and Joint Surg, 13, 273, April, 1931
PEABODY, C W, and MURO, F Congenital Metatarsus Varus, Jour Bone and Joint Surg, 15, 171, January, 1933
PERKINS, G Removal of the Metatarsal Head for Hallux Valgus and Hallux Rigidus, Lancet, 1, 540, March, 1927
PERTHES, G Über modellierende Osteotomie bei Plattfussen mit schowerer Knochendeformität, Zentralbl f Chir, 40, 548, 1913
PHEMISTER, D B Changes in Articular Surfaces in Tuberculous and in Pyogenic Infections of Joints, Am Jour Roentgenol, 12, 1, July, 1924
——— Chronic Fibrous Osteomyelitis, Ann Surg, 90, 756, October, 1929
PLATT, H Fractures in the Neighborhood of the Ankle-joint, Lancet 1, 33, 1926
POLLOCK, L J Christopher's Text Book of Surgery, 2d ed, Philadelphia, W B Saunders Company, 1939
POLLOCK, L J, and DAVIS, L Peripheral Nerve Injuries, New York, Paul B Hoeber, Inc, 1932
PORTER, John L Some Further Notes on the Treatment of Bunions, Surg, Gynec and Obst, 26, 460-463, 1918
PREISER, G Static Joint Diseases, Their Etiology and Their Relation to Arthritis Deformans, Am Jour Orthop Surg, 10, 100, August, 1912
Queries and Minor Notes Gout, Jour Am Med Assn, 110, No 15, April 9 1938
QUIGLEY, T B, COX, JAMES, and MURPHY, JOSEPH A Protective Wrapping for the Ankle, Jour Am Med Assn, 132 924, 1946
QUIRING, D P, BOYLE, B A, BOROUSH, E L, and LUPKIN, B The Extremities Philadelphia, Lea & Febiger, 1945
REICH, R S The Present Status of Treatment of Fractures of the Calcaneus Surg, Gynec and Obst, 68, 302, March, 1939
ROBERTS, P W Fifty Cases of Bursitis of the Foot, Jour Bone and Joint Surg, 11, 338, April, 1929
——— Bursitis of the Foot, Med Times New York, 58, 105-107, April, 1930
ROTHBERG, A S, FELDMAN, J W, and SCHUSTER, O F Congenital Fusion of Astragalus and Scaphoid Bilateral, Inherited, New York State Jour Med, 35 29, 1935
ROYLE, N D A New Conception in the Etiology of Claw foot and Associated Talipes Equinus, Jour Bone and Joint Surg, 9, 465, July, 1927
RYERSON, E W Arthrodesing Operations on the Feet, Jour Bone and Joint Surg, 5 453, July, 1923
SABOTTA and MCMURRICH Atlas of Human Anatomy, Munich, J F Lehmanns, vol 1, 1930
SAMUELS, SAUL S Fundamental Principles in Treatment of Diabetic Gangrene, Surgery, 2, 225-237, August, 1937
SAUNDERS J T Etiology and Treatment of Clawfoot, Arch Surg, 30, 179 February, 1935

Scheman, L., Lewin, P., and Soskin, S.: Progressive Pseudo-hypertrophic Muscular Dystrophy, Jour. Am. Med Assn., **111**, 2265–2268, December, 1938.

Scholz, Roy Philip, and Mountjoy, Philip S.: Fiberglas Suture Material, Am. Jour. Surg., **56**, 619–621, 1942.

Schoolfield, B. L.: Operation for Cure of Flat-foot, Ann. Surg., **110**, 437, 446, September, 1939.

Schwartz, R. P.: The Determination of Pre-operative Indications for Correction of Bone Deformities, Jour. Bone and Joint Surg., **11**, 385, April, 1929.

Schwartz, R. P., Heath, A. L., Misiek, W., and Wright, J. N.: Kinetics of Human Gait, Jour. Bone and Joint Surg., **16**, 343, 1934.

Schwartz, R. P., Heath, A. L., and Wright, J. N.: Electrobasographic Method of Recording Gait, Arch. Surg., **27**, 926, 1933.

Scott, Walter: March Fractures, Surg., Gynec. and Obst., **81**, 525, 1945.

Shaeffer, L. W.: Subungual Exostoses, Arch. Derm. and Syph., **24**, 371–379, September, 1931.

Shands, A. R., Jr.: The Accessory Bones of the Foot, South. Med. and Surg., **93**, 326, May, 1931.

——— Handbook of Orthopedic Surgery, 2d ed., C. V. Mosby Co., 1940.

——— The Incidence of Subastragaloid Dislocation of the Foot With a Report of One Case of the Inward Type, Jour. Bone and Joint Surg., **10**, 306, April, 1928.

Sicard, A., and Mutricy, H.: A propos du traitement chirurgical des fractures sous thalamiques du calcaneum, Jour. de chir., **43**, 374, 1934.

Sideman, S.: An Intrinsic Elevator for Leg Casts, Jour. Bone and Joint Surg., **21**, 1045, October, 1939.

Sigfried, Block, and Standlee, T. H.: Nocturnal Cramps in the Legs; In Queries and Minor Notes, Jour. Am. Med. Assn., p. 471, February 12, 1944.

Silbert, S.: Amputations in Thrombo-angiitis Obliterans, Surg. Clin. North America, **18**, 389–403, April, 1938.

Silver, D.: The Operative Treatment of Hallux Valgus, Jour. Bone and Joint Surg., **5**, 225, April, 1923.

Simpson, G. C. E., and Dunn, N.: On Spasmodic Contraction of the Peronei in Flat-foot, Brit. Med. Jour., **2**, 1369–1371, 1912.

Sirbu, A. B., Murphy, M. J., and White, A. S.: Soft Tissue Complications of Fractures of the Leg, California Western Med., **60**, 53, 1944.

Sloane, D.: Congenital Hallux Valgus: Operative Correction, Jour. Bone and Joint Surg., **17**, 209–211, January, 1935.

Sloane, D., and Sloane, M. F.: March Foot, Am. Jour. Surg., **31**, 167–169, January, 1936.

Smith, A. DeF., and von Lackum, H. L.: End Results of Operation for Claw-foot, Jour. Am. Med. Assn., **84**, 499, 1925.

Smith, Hugh: Subastragalar Dislocation; A Report of Seven Cases, Jour. Bone and Joint Surg., **19**, 373–380, April, 1937.

Smith, J. L., Ritchie, J., and Dawson, J.: Clinical and Experimental Observations on the Pathology of Trench Frostbite, Jour. Path. and Bact., **20**, 159–190, 1915.

Smithwick, Reynold: Modified Dorsal Sympathectomy for Vascular Spasm (Raynaud's Disease) of the Upper Extremity, Ann. Surg., **104**, 339, 1936.

Solley, Fred W.: Symposium on the Mortality of Amputations for Diabetic Gangrene; Diabetic Lower Extremity Amputations.

Soule, R. E.: Value of Bone Pin Arthrodesis in the Treatment of Flat-foot, Jour. Am. Med. Assn., **77**, 1871, 1921.

Soutter, R.: Technique of Operations on the Bones, Joints, Muscles and Tendons, New York, Macmillan Co., p. 118, 1917.

Speed, J. S., and Blake, T. H.: March Foot, Jour. Bone and Joint Surg., **15**, 372, 1933.

Speed, J. S., and Boyd, H. B.: Operative Reconstruction of Malunited Fractures About the Ankle Joint, Jour. Bone and Joint Surg., **15**, 903, October, 1933.

——— Operative Reconstruction of Malunited Fractures About the Ankle Joint, Jour. Bone and Joint Surg., **18**, 270, 1936.

SPEED, K A Discussion of Pott's Fracture With Complications Based on a Series of 208 Cases, Surg, Gynec and Obst, 19, 73, July, 1914

SPEIGEL, I JOSHUA, and LEWIN, PHILIP Tourniquet Paralysis Analysis of Three Cases of Surgically Proved Peripheral Nerve Damage Following Use of Rubber Tourniquet, Jour Am Med Assn, 129, 432–435, 1945

SPITZY, H Operative Correction of Claw-foot, Surg, Gynec and Obst, 45, 813, December, 1927

STEINDLER, A Mechanics of Normal and Pathological Locomotion in Man Springfield, Charles C Thomas 1935

——— A Textbook of Operative Orthopedics, New York, D Appleton & Co, 1925

——— Stripping of the Os Calcis, Jour Orthop Surg, 2, 8, January, 1920

——— Orthopædic Operations, Springfield, Charles C Thomas, 1940

STEINDLER, ARTHUR, and SMITH, ALBERT R Spurs of the Os Calcis, Surg, Gynec and Obst, 66, 663–665, 1938

STOFFEL, A The Treatment of Spastic Contractures, Am Jour Orthop Surg, 10, 611, May, 1913

STRAUS, D C Subtalus Dislocation of the Foot With Report of Two Cases, Am Jour Surg, 30, 427, 1935

SULLIVAN, J E The After care of Amputation Stumps, Surg Clin North America, 18, 433, April, 1938

SYME, JAMES Jour Med Sci (London and Edinburgh), 3, 93–96, 1843

TELFORD, E D The Technique of Sympathectomy, Brit Jour Surg, 23, 448, 1935

THOMAS, H O Contributions to Medicine and Surgery, 1874 *et seq*

——— A New Wrench for Club-foot, Providence Med Jour, p 286, 1886

THOMPSON, STUART A The Denis Browne Club foot Splint, Jour Bone and Joint Surg, April, 1942

THOMPSON, T C Astragalectomy and the Treatment of Calcaneovalgus, Jour Bone and Joint Surg, 21, 627, 1939

THOMSON, J E M, HELWIG, F, and SIRE, E Sympathetic Block in the Treatment of Local Shock, Jour Bone and Joint Surg, 26, 189, January, 1944

THORNDIKE, AUGUSTUS Athletic Injuries, Prevention, Diagnosis and Treatment, Philadelphia, Lea & Febiger, 1942

TITUS, N E Physical Therapy in the Treatment of Amputation Stumps, Surg Clin North America, 18, 483, April, 1938

TODD, A H Aetiology and Treatment of Spasmodic Flat-foot, Brit Med Jour, 2, 602–604, 1939

TOMPKINS, C A, CROOK, G W, HAYNES, E, and WINTERS, M Pectin in the Treatment of Various Types of Wounds, Surg, Gynec and Obst, 72, 222, February, 1941

TRETHOWAN, W H Discussion, Proc Roy Soc Med (Section of Orthop), 23, 984, 1930

——— Fractures in the Neighborhood of the Ankle Joint Lancet, 1, 90, January, 1926

TRUETA, J "Closed" Treatment of War Fractures, Lancet, 1, 1452, 1939

——— Treatment of War Wounds and Fractures, New York, Paul B Hoeber, Inc, 1940

TRUSLOW, W Metatarsus Primus Varus or Hallux Valgus, Jour Bone and Joint Surg, 7, 98–108, 1925

UNKE, J Treatment of Helomata, Nat Assn Chiropodists, 36, July, 1946

VEAL, J R The Pathologic Basis for Intermittent Claudication in Arteriosclerosis, Am Heart Jour, 14, 442, 1937

VEAL J R, and MCFETRIDGE, ELIZABETH M Vascular Changes in Intermittent Claudication With a Note on the Value of Arteriography in This Symptom Complex, Am Jour Sci, 192, 113, 1936

VOGT P R Ischemic Muscular Necrosis Following Marching Unpublished, But Read Before the Oregon State Medical Society, September 4, 1943

VON LACKUM, H. L.: Operations in Treatment of Spastic Paralysis, Jour. Bone and Joint Surg., 7, 590, July, 1926.

VON LANZ, T., and WACHSMUTH, W.: Praktische Anatomie. Ein Lehr- und Hilfsbuch der anatomischen Grundlagen ärztlichen Handelns, Band, 1, Teil 4, Berlin, Julius Springer, 1939.

WAGNER, L. C.: Ankle Bone Block for Paralytic Drop-foot, Ann. Surg., 101, 1091, April, 1935.

WAGONER, GEORGE W.: Bilateral Congenital Fusion of Calcanei and Cuboids, Jour. Bone and Joint Surg., 10, 220–223, April, 1928.

The Medical Department of the United States Army in the World War, Vol. XI, Surgery, Part 1, General Surgery, Orthopædic Surgery, Neurosurgery, p. 72, War Department, 1927.

The Medical Department of the United States Army in the World War, Vol. XV, Statistics, Part 2, Medical and Casualty Statistics, pp. 15, 17, 1017, and 1019, War Department, 1925.

WATSON-JONES, R.: Fractures and Joint Injuries, 3d ed., II, p. 702, Baltimore, Williams & Wilkins Co., 1943.

WEBSTER, D. R, WOOLHOUSE, F. M., and JOHNSTON, J. L.: Immersion Foot, Jour. Bone and Joint Surg., 24, 785–791, 1942.

WEICHEC, F. J., and KRUSEN, F. H.: A New Method of Joint Measurement and a Review of the Literature, Am. Jour. Surg , 43, 659, March, 1939.

WHITE, CLEVELAND: Rôle of Fungi in Occupational Skin Diseases, Illinois Med. Jour., 56, 219, September, 1929.

——— Diagnostic Blocking of Sympathetic Nerves to the Extremity with Procaine, Jour. Am. Med. Assn., 94, 1382, 1930.

——— Painful Oedema of the Extremities in Shipwrecked Mariners. A Newly Recognized Syndrome Occurring After Prolonged Dehydration, Malnutrition, and Vitamin Deficiency in Southern Waters, U. S. Naval Med. Bull. (January, 1943).

——— Vascular and Neurologic Lesions in Survivors of Shipwreck. II. Painful Swollen Feet Secondary to Prolonged Dehydration and Malnutrition, New England Jour. Med., 228, 241–217, 1943.

WHITE, J. C., and WARREN, S.: The Causes of Pain in the Feet After Prolonged Immersion in Cold Water. To be Published in War Medicine.

WHITE, J. WARREN: Torsion of the Achilles Tendon; Its Surgical Significance, Arch. of Surg., 46, 784–787, 1943

WHITMAN, R.: The Operative Treatment of Paralytic Talipes of the Calcaneus Type, Am. Jour. Med. Sci , 122, 593, 1901.

——— Orthopædic Surgery, 9th ed., Philadelphia, Lea & Febiger, 1930.

——— The Importance of Positive Support in the Curative Treatment of Weak Feet and a Comparison of the Means Employed to Assure It, Am. Jour. Orthop Surg., 11, 215, October, 1913.

WILSON, PHILIP D.: Frac[illegible] Dislc[illegible] Tarsal Bones, South. Med. Jour., 21, 833–845, [illegible]

——— Syme's Amp[illegible] 711–728, June, 1921.

——— Treatment [illegible] odesis of the Subastragalar Joint; Repo[illegible] 89, 1676, November, 1927.

——— Management [illegible] ippin[illegible] [illegible] pany, 193[illegible]

W[illegible] March[illegible] [illegible]d.

[illegible]r, 1914 [illegible]

[illegible] NE G. [illegible]

[illegible]ction, [illegible]

[illegible]: Or[illegible] [illegible]31, B[illegible] [illegible] for C[illegible]

ZADEK, I Transverse wedge Arthrodesis for the Relief of Pain in Rigid Flat-foot, Jour Bone and Joint Surg, 17, 453, 1935

ZADEK, I, and BARNETT, E. L The Importance of the Ligaments of the Ankle in Correction of Club foot, Jour Am Med Assn, 49, 1057, September 29, 1917

ZEITLIN, A A, and ODESSKY, I N "Pied forcé" or "Deutschländer's Disease," Radiology, 25, 215–222, August, 1935

ZIMMERMAN, L M Phlebitis, Thrombosis, and Thrombophlebitis of the Lower Extremities, Surg, Gynec and Obst, 61, 443–457, 1935

———— Pathogenesis of the Cutaneous Complications of Varicose Veins, Arch Dermat and Syph, 34, 97–102, 1936

———— Modern Management of Varicose Veins, Illinois Med Jour, 71, 444–447, 1937

ZIMMERMAN, L M, and FALLER, A, JR Etiology and Treatment of Ulcers of the Leg, Surg, Gynec and Obst, 70, 792–798, 1940

ZIMMERMAN, LEO M, THODE, PAUL FALLER, JR, ADOLPH, and HELLER, RICHARD E Varicose Veins and Their Complications, Quart Bull, North Univ Med Sch, 14, 146, Chicago, 1940

Von Lackum, H. L.: Operations in Treatment of Spastic Paralysis, Jour. Bone and Joint Surg., 7, 590, July, 1926.

von Lanz, T., and Wachsmuth, W.: Praktische Anatomie. Ein Lehr- und Hilfsbuch der anatomischen Grundlagen arztlichen Handelns, Band, 1, Teil 4, Berlin, Julius Springer, 1939.

Wagner, L. C.: Ankle Bone Block for Paralytic Drop-foot, Ann. Surg., 101, 1091, April, 1935.

Wagoner, George W.: Bilateral Congenital Fusion of Calcanei and Cuboids, Jour. Bone and Joint Surg., 10, 220–223, April, 1928.

The Medical Department of the United States Army in the World War, Vol. XI, Surgery, Part 1, General Surgery, Orthopædic Surgery, Neurosurgery, p. 72, War Department, 1927.

The Medical Department of the United States Army in the World War, Vol. XV, Statistics, Part 2, Medical and Casualty Statistics, pp. 15, 17, 1017, and 1019, War Department, 1925

Watson-Jones, R.: Fractures and Joint Injuries, 3d ed., II, p. 702, Baltimore, Williams & Wilkins Co., 1943.

Webster, D. R., Woolhouse, F. M., and Johnston, J. L.: Immersion Foot, Jour. Bone and Joint Surg., 24, 785–794, 1942.

Weichec, F. J., and Krusen, F. H.: A New Method of Joint Measurement and a Review of the Literature, Am. Jour. Surg., 43, 659, March, 1939.

White, Cleveland: Rôle of Fungi in Occupational Skin Diseases, Illinois Med. Jour., 56, 219, September, 1929.

——— Diagnostic Blocking of Sympathetic Nerves to the Extremity with Procaine, Jour. Am. Med. Assn., 94, 1382, 1930.

——— Painful Oedema of the Extremities in Shipwrecked Mariners. A Newly Recognized Syndrome Occurring After Prolonged Dehydration, Malnutrition, and Vitamin Deficiency in Southern Waters, U. S. Naval Med. Bull. (January, 1943).

——— Vascular and Neurologic Lesions in Survivors of Shipwreck. II. Painful Swollen Feet Secondary to Prolonged Dehydration and Malnutrition, New England Jour. Med., 228, 241–247, 1943.

White, J. C., and Warren, S.: The Causes of Pain in the Feet After Prolonged Immersion in Cold Water. To be Published in War Medicine.

White, J. Warren: Torsion of the Achilles Tendon; Its Surgical Significance, Arch. of Surg., 46, 784–787, 1943

Whitman, R.: The Operative Treatment of Paralytic Talipes of the Calcaneus Type, Am. Jour. Med. Sci., 122, 593, 1901.

——— Orthopædic Surgery, 9th ed., Philadelphia, Lea & Febiger, 1930.

——— The Importance of Positive Support in the Curative Treatment of Weak Feet and a Comparison of the Means Employed to Assure It, Am. Jour. Orthop. Surg., 11, 215, October, 1913.

Wilson, Philip D.: Fractures and Dislocations of the Tarsal Bones, South. Med. Jour., 21, 833–845, 1933.

——— Syme's Amputation, S. Clin. North America, 1, 711–728, June, 1921.

——— Treatment of Fractures of the Os Calcis by Arthrodesis of the Subastragalar Joint; Report on 26 Cases, Jour. Am. Med. Assn., 89, 1676, November, 1927.

——— Management of Fractures and Dislocations, Philadelphia, J. B. Lippincott Company, 1938.

Wilson, P. R.: March Fracture; A Series of 64 Cases, Jour. Royal Army Med. Corps, October, 1944.

Wright, Wilhelmine G.: Crutch-walking As An Art, Am. Jour. Surg., 1, 372, December, 1926.

——— Muscle Function, Paul B. Hoeber, Inc., 1928.

Young, Charles S.: Operative Treatment of Pes Planus, Surg., Gynec. and Obst., 68, 1099–1101, 1939

Zadek, I.: Operation for Cure of Achillobursitis, Am. Jour. Surg., 43, 542–546 February, 1939.

ZADEK, I Transverse-wedge Arthrodesis for the Relief of Pain in Rigid Flatfoot, Jour Bone and Joint Surg, 17, 453, 1935

ZADEK, I, and BARNETT, E L The Importance of the Ligaments of the Ankle in Correction of Club foot, Jour Am Med Assn, 49, 1057, September 29, 1917

ZEITLIN, A A, and ODESSKY, I N "Pied forcé" or "Deutschlander's Disease," Radiology, 25, 215–222, August, 1935

ZIMMERMAN, L M Phlebitis, Thrombosis, and Thrombophlebitis of the Lower Extremities, Surg, Gynec and Obst, 61, 443–457, 1935

——— Pathogenesis of the Cutaneous Complications of Varicose Veins, Arch Dermat and Syph, 34, 97–102, 1936

——— Modern Management of Varicose Veins, Illinois Med Jour, 71, 444–447, 1937

ZIMMERMAN, L M, and FALLER, A, JR Etiology and Treatment of Ulcers of the Leg, Surg, Gynec and Obst, 70, 792–798, 1940

ZIMMERMAN, LEO M, THODE, PAUL, FALLER, JR, ADOLPH, and HELLER, RICHARD E Varicose Veins and Their Complications, Quart Bull, North Univ Med Sch, 14, 146 Chicago, 1940

INDEX

A

Q

R

T

X

Y

Z